User's Manual

SIMPROCESS

Release 4

CACI

Copyright © 2004 CACI Products Company
January 2004

All rights reserved. No part of this publication may be reproduced by any means without written permission from CACI.

The information in document is believed to be accurate in all respects. However, CACI cannot assume the responsibility for any consequences resulting from the use thereof. The information contained herein is subject to change. Revisions to this publication or new editions of it may be issued to incorporate such change.

SIMPROCESS is a registered trademark of CACI Products Company.

Organization of the SIMPROCESS Documentation Set..... 10

Part A
SIMPROCESS Functions and Features 12

CHAPTER 1
Process Modeling and Analysis with SIMPROCESS..... 13

What is SIMPROCESS? 15
How Do You Use SIMPROCESS? 16
SIMPROCESS Editions 17
SIMPROCESS Terminology and Menus 18

CHAPTER 2
SIMPROCESS Basics 53

Using the Palette Bar to Create Activities 57
Generate Activity 63
Delay Activity 66
Dispose Activity 69
Defining an Entity 70
Defining Resources and Processes 73
Simulation Setup 77
Running a Simulation 80
Standard Report 82

CHAPTER 3
Statistical Modeling Constructs 83

Random Number Generation and Standard Distributions 85
User Defined Distributions 87
Run Settings 90

CHAPTER 4
Activity Modeling Constructs *94*

Entity-Related Activities **96**
Entity Control Activities **107**

CHAPTER 5
Resource Modeling Constructs *126*

Resources and Simulation **127**
Defining Resources **128**
Adding Resource Requirements to Activities **131**
Explicitly Getting and Freeing Resources **133**
Replenishing Consumable Resources **137**
Preempting Lower Priority Entities **139**

CHAPTER 6
Graphical Modeling Constructs *140*

Background Text **141**
Background Graphics **145**
Importing Graphics Image Files **146**
Post Simulation Animation **149**

CHAPTER 7
Activity-Based Costing *153*

ABC and SIMPROCESS **154**
Benefits of ABC with SIMPROCESS **155**
How to Use ABC in SIMPROCESS **156**

CHAPTER 8
Output Reports *162*

Standard Report **163**

Custom Statistics **165**
Real-Time Plots **176**
Custom Plots **185**
Simulation Results File **195**

Part B
Advanced SIMPROCESS Functions and Features **196**

CHAPTER 9
Reusable Templates and Libraries ***197***

Library Concepts **198**
Defining and Editing Templates **199**
Editing Templates **207**
Advantage of Templates Over Copy/Paste **209**

CHAPTER 10
Customizing a Model with Attributes and Expressions ***210***

Introduction to Attributes and Expressions **212**
Using Attributes in SIMPROCESS **214**
User Defined Attributes **215**
Assign Activity **222**
Variable Resource Usage **224**
Writing Expressions **226**
Evaluate (Evl) Function **235**
Expression Activation Events **236**
Attribute Value Initialization **241**
Example: Batching Entities Based on Weight **242**
Getting and Freeing Resources Using Expressions **253**
Changing Resource Capacity With Expressions **256**
User-Defined Functions **257**
Dynamic Labels **258**
Interfacing With A Database **260**

Accessing Statistics During Simulation..... 267
Summary..... 274

CHAPTER 11
More Advanced Model Building..... 275

Defining a More Complex Generate Activity..... 276
Resource Downtime..... 294
Event Logs..... 309

Part C
Advanced SIMPROCESS Tools..... 313

CHAPTER 12
Advanced Data Analysis..... 314

An Introduction to Data Analysis and Modeling..... 316
Why Statistical Simulation Experiments?..... 319
SIMPROCESS Statistical Distributions..... 320

CHAPTER 13
SIMPROCESS Database..... 322

Committing Results to the Database..... 323
System, Design, and Scenario..... 324
Database Table Relationships..... 326
Database Queries..... 327
Forms (Graphs) and Reports..... 329
Launch Database Application..... 331
SIMPROCESS and Other Databases..... 332

CHAPTER 14
Experiment Manager *334*

Defining Experiments **335**
Running Experiments **342**
Experiment Operation **344**
Importing Database Experiments **348**

CHAPTER 15
OptQuest for SIMPROCESS *349*

Overview of OptQuest for SIMPROCESS **350**
Optimization Setup **352**
Running an Optimization **364**
Tips and Suggestions **371**
OptQuest Demonstration Models **377**

CHAPTER 16
SIMPROCESS Dashboards *379*

Defining Dashboards **380**
Assigning Dashboards **390**
Displaying Dashboards **395**

Appendices **399**

APPENDIX A
Importing Version 2.2.1 Models *400*

Import Procedures **401**
Preparing Your Model For Import **402**
Graphical Import Results **405**
Properties Import Results **413**
Importing Document Files **416**

APPENDIX B
Activity Summary Table ***417***

APPENDIX C
SIMPROCESS File Structure ***420***

APPENDIX D
Statistical Distributions ***425***

Uniform Distribution **427**
Normal Distribution **428**
Triangular Distribution **429**
Exponential Distribution **430**
Gamma Distribution **431**
Beta Distribution **432**
Erlang Distribution **433**
Weibull Distribution **434**
Lognormal Distribution **435**
Poisson Distribution **436**
Hyper Exponential Distribution **437**
Uniform Integer Distribution **438**
Geometric Distribution **439**
Pareto Distribution **440**
Binomial Distribution **441**
Negative Binomial Distribution **442**
Inverse Gaussian Distribution **443**
Inverted Weibull **444**
Johnson SB Distribution **445**
Johnson SU Distribution **446**
Log-Logistic Distribution **447**
Log-Laplace Distribution **448**
Pearson Type V Distribution **449**
Pearson Type VI Distribution **450**
Random Walk Distribution **451**

APPENDIX E
Statistical Tools Glossary *452*

APPENDIX F
SIMPROCESS System Attributes and Methods *458*

System Attributes **459**
SIMPROCESS System Methods **465**
System Method Examples **480**
SIMPROCESS Color Table **497**

APPENDIX G
External Event Files *498*

General Rules for Event Files **499**
Event Record Description **501**
Examples **503**

APPENDIX H
Simulation Results File *504*

Format of the Simulation Results File **505**

APPENDIX I
UML Interfaces *512*

Exporting to UML **514**
Rose Use Cases **516**

APPENDIX J
Running Models Without GUI *519*

Organization of the SIMPROCESS Documentation Set

The SIMPROCESS documentation set consists of three manuals:

- *Getting Started With SIMPROCESS*
- *SIMPROCESS User's Manual*
- *ExpertFit for SIMPROCESS User's Guide*

Getting Started

The *Getting Started With SIMPROCESS* manual is a must for first time SIMPROCESS users. This manual can also be used for evaluation purposes. Chapter 1 provides an overview of Process Modeling and Analysis and the SIMPROCESS product. Chapter 2 provides system requirements and installation instructions. Chapters 3 and 4 of the *Getting Started With SIMPROCESS* manual provides a tutorial, and Chapter 5 provides a description of the demonstration and reference models.

User's Manual

The *User's Manual* is distributed in electronic format with SIMPROCESS. It can be opened directly from the SIMPROCESS Installation CD or from the **Help/On-line Documentation** menubar option.

The *User's Manual* is divided into three parts. Part A is an excellent reference for beginners and casual users. This part contains a detailed documentation of the basic and intermediate functions of SIMPROCESS. Chapters 1 and 2 provide SIMPROCESS terminology and basics. Chapter 3 provides a detailed description of SIMPROCESS Statistical Constructs and their use. Chapter 4 describes in detail how the SIMPROCESS Activity Modeling blocks are used. Chapter 5 describes the use of Resources. Graphical Modeling Constructs are covered in Chapter 6. Chapter 7 is dedicated to Activity-Based Costing, and Chapter 8 covers the Output Reports for analysis.

Part B is a reference intended for advanced users of SIMPROCESS. This part contains a detailed documentation of the programming and library management functions in SIMPROCESS Professional. Chapter 9 provides documentation of the Reusable Templates and Library Management. Chapter 10 covers the advanced SIMPROCESS constructs such as attributes, expressions, and timestamps. Chapter 11 wraps up the advanced features of SIMPROCESS with descriptions of the complex features of the Generate activity and Downtime Schedules for Resources.

Part C describes the integrated statistical tools included with SIMPROCESS Professional. Chapter 12 of this manual provides an introduction to data analysis and ExpertFit. Chapter 13 covers using the SIMPROCESS Database, while Chapter 14 discusses using the Experiment Manager. How to perform optimization using OptQuest is discussed in Chapter 15. Chapter 16 discusses SIMPROCESS Dashboards.

ExpertFit for SIMPROCESS User's Guide

ExpertFit determines automatically and accurately which probability distribution best represents a data set. This guide describes how to use ExpertFit in association with SIMPROCESS. It includes an appendix that gives descriptive information on each distribution in SIMPROCESS.

Part A
SIMPROCESS Functions and Features

The chapters in Part A describe the basic functions and features of SIMPROCESS.

CHAPTER 1

Process Modeling and Analysis with SIMPROCESS

The goal of Process Modeling is to create a simplified but useful model of a business enterprise. The enterprise can be a small work group or development team, a particular division, a related set of departments, or even an entire company. The model allows an analyst to study the Processes in a business in order to:

- Determine bottlenecks or wasted effort
- Devise revisions to the Process to correct performance problems
- Select Process designs that give the best results
- Provide cost justification
- Establish performance targets for the new Process implementation.

Many types of tools and techniques are available for Process Modeling. Frequently, a simple diagram or flowchart can expose the obvious redundancies, unnecessary work, and inefficiencies in a given Process. Tools which provide simple diagramming of a Process are called *static modeling tools*. However, to expose less obvious bottlenecks and costs intrinsic to the Process requires information about the resources employed in the Process, measurements of the Processing capacity of the resources, and some measure of the expected workflow through the Process.

Many Process modeling tools today do not allow a quantified analysis of the Process under study. Some of those do not take into account the:

- Time-varying nature of many Processes
- Non-linear interactions among elements of a Process
- Random behavior of most real Processes
- Unexpected events in the business environment

The bottom line is that most Processes are not well characterized by deterministic, mathematical models. A dynamic business Process modeling tool, which can simulate the behavior of the Process as it responds to the events occurring in the business environment, is required to analyze time-varying business processes.

Why Dynamic Modeling?

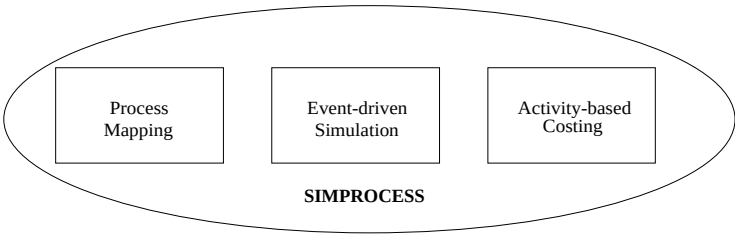
A computerized dynamic model simulates the flow of materials and information through the Process. The dynamic model accounts for the random variations in how work is done and the way materials (and information) flow through the real world. Simulation offers several advantages over a simple pictorial abstraction of a business Process. SIMPROCESS employs discrete event simulation to capture the time-varying nature of the Process under study.

SIMPROCESS advantages include:

- First, the analyst can correlate the data produced by the model with measurements taken from the real Processes to increase certainty that the model has adequately captured the essential features of the real Process.
- Second, the model will generate quantified Process measurements such as: excess capacity or bottlenecks, the time it takes work items to flow through the Process, and the percentage of time expended in value-adding Processes versus non-value-adding Processes.
- Third, the model allows the analyst to evaluate, in quantified terms, the effects of reengineering the Process.

What is SIMPROCESS?

SIMPROCESS is a hierarchical and integrated Process simulation tool that radically improves your productivity for Process modeling and analysis. SIMPROCESS is designed for BPR and IT professionals of industrial and service enterprises who need to reduce the time and risk it takes to service customers, fulfill demand, and develop new products.



SIMPROCESS integrates Process mapping, hierarchical event-driven simulation, and Activity-based costing (ABC) into a single tool. The architecture of SIMPROCESS provides an integrating framework for ABC. The building blocks of SIMPROCESS are Processes, resources, entities (flow objects), activities, ABC, and dynamic Process analysis. ABC embodies the concept that a business is a series of inter-related Processes, and that these Processes consist of Activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an Activity basis.

How Do You Use SIMPROCESS?

SIMPROCESS allows you to create an abstract model of a Process under study. You produce a computer model of a business Process and documentation (diagrams and descriptions) to be printed.

SIMPROCESS is a *dynamic modeling tool* that simulates the flow of entities through the defined Process. Entities could be:

- proposals
- orders
- invoices
- customers
- work-in-Process
- patients.

Items, Entities, that a Process receives, acts upon, or produces should be included in the definition of the business Process. Items flow from one Process step to the next and at each step some task is performed. The Resources, such as people, machines, or information required to complete the tasks are also included in the business model.

SIMPROCESS generates valuable information about the Activities, Entities, and Resources in the model. This data is used to validate the Process model. The generated statistics and reports are used to determine where the Process could be improved. SIMPROCESS allows you to evaluate alternatives and different management policies. SIMPROCESS helps a team decide which changes to a business Process will provide the most benefits.

SIMPROCESS Editions

SIMPROCESS has three editions:

- Professional Edition - contains all the features and capabilities of SIMPROCESS. There are no limits on model size for models built with SIMPROCESS Professional Edition.
- University Edition - also contains all the features and capabilities of SIMPROCESS. However, model sizes are limited to no more than 50 Processes and Activities.
- Runtime Edition - models are limited to no more than 50 processes and activities, 5 entity types, and 5 resource types. Also, none of the advanced features are accessible.

SIMPROCESS Terminology and Menus

SIMPROCESS Terminology

This manual uses the following words and definitions in its description of SIMPROCESS.

Activities. An Activity is a basic step in a model where an operation is performed on an entity. Examples of Activities are Generate, Delay, and Dispose. An Activity may or may not involve passage of time or requirements.

Attributes are system and user-defined variables of model elements whose value can change during the course of a simulation run. Attributes may be used to alter the behavior of a Process by changing their value during a simulation. They can also be used to communicate information (such as system time) between two Processes in a model or store data collected during a simulation run.

Connectors link Activities and Processes together and are paths used by entities to flow through the model.

Cycle time. An Entity's cycle time is the sum of the Processing times and delays it encounters as it is processed in the model.

Entities represents people, goods, or information. Most are produced as a result of a Process or Activity.

Entities are generally created at the Generate Activity, although other Activities (e.g., Batch, Assemble) may produce entity instances as well. Entities must enter a Dispose Activity to ensure statistics collection.

Hierarchical Processes. The concept of a Process provides hierarchical modeling capabilities. A Process is a collection of Activities and sub-Processes organized as a model network.

Layout contains graphical representations of the Activities, Processes, and Connectors that make up a SIMPROCESS model. The entities only appear on the layout while the simulation is running. The layout can be made to resemble the physical layout of a system, or it can be closer in appearance to a flow diagram.

Model is a representation of the system being studied. It is not intended to be an exact duplicate of the system, but rather a simplified version that captures the relevant features.

Pads are small triangular graphic objects located along the border of an Activity or Process. Pads are used for connecting connectors to the inputs and outputs of the Activity/Process. Entities enter and exit Activities through input and output pads.

Alternative Process/Sub-Process. Alternative Processes define alternative behaviors or flows of a

Process. Multiple alternatives can be associated with a Process, but only one can be active at a time.

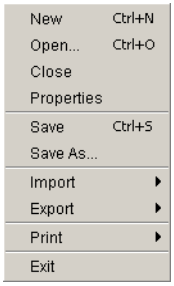
Resources are the agents required to perform an Activity. People, computers, and trucks are all examples of Resources. Resources may be consumable (e.g., oil or paper) or reusable (e.g., trucks).

Simulation is defined as the reproduction of the dynamic and random behavior of a business Process with the goal of quantifying some key characteristics of the business Process.

Templates of Activities, Processes, and Resources can be stored in a library for reuse.

SIMPROCESS Menus

File Menu



New creates a new model file.

Open loads a previously saved model.

Close closes the active model.

Properties opens a dialog that tracks the edit history of a model.

Save saves the model.

NOTE: It is a good idea to save a model any time you make changes to it and to save a model under a different name any time you extensively change a model. SIMPROCESS saves your models with the extension `.spm` and at the same time also saves a backup with the extension `.bck`. To save a new model or to save an existing model under a new name, use **File/Save As...**. For information on automatic saving, see "Other Preferences" on page 26.

Save As... is used to save a model for the first time, or to save a model with a new name.

Import

Version 2.2.1 Model... lets you import a SIMPROCESS version 2.2.1 or 2.2.2 model. Due to changes in the graphical coordinate system from earlier versions of SIMPROCESS to the current version, some cleanup may be required. See "Importing Version 2.2.1 Models," beginning on page 400 for more information.

Background... imports a Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG or JPG), or Portable Network Graphics (PNG) file for use as a background image.

Export

Graphics Image File... creates a JPEG image of the current layout.

Simulation Results... exports the results of the current model to a tab-delimited file. The data from all reports selected for the current model will be written to this file. The file can be opened with a text editor or spreadsheet.

Activity List... outputs the Process and Activity hierarchy to an ASCII file.

UML Activity Model... outputs the model to a UML-compatible file. This feature is disabled in the SIMPROCESS Runtime version. See "UML Interfaces" on page 512.

Publish Model to HTML... outputs the model to HTML format to be made accessible via a standard web browser. Select a destination directory, and a new directory will be created with the same name as the model (with any spaces replaced by underscores).

All layouts will be exported to JPEG image files with web pages built around them. Lists of the model's Activities, Processes, Resources, Entities, and each type of Global Attribute will be provided, including links to the properties of each. The Standard Report data will be included along with any plots that are available via the Display Real-Time Plots menu item, if the model had been executed.

Print

Print Layout... prints a picture of the current model layout, including background icons, but the layout color will not be printed.

Print Model... prints a picture of each screen of the model. The first page is a table of contents.

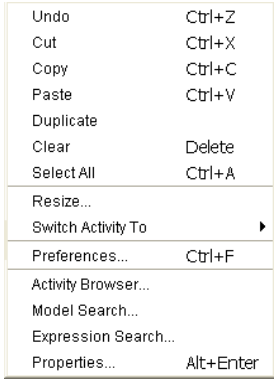
Process Documentation... prints the descriptions of selected Processes. The following is a sample Process documentation printout.

Model Documentation... prints the description of all elements of the model. This includes **Name**, **Path**, and **Comment** field entries of all Activities/Processes, Entities, and Resources in the model. Any information you have added using the **Document** button is also included.

List of Most Recently Used Models. The **File** menu contains a list of the most recently used models. Open any of these models by clicking on its name. The number of recent files is set on the **Edit/Preferences** dialog.

Exit quits SIMPROCESS. If you have made edits since you last saved the open models, you will be prompted to save your models before exiting.

Edit Menu



Undo

Undo restores Activities, Processes, and Connectors that have been cut or cleared (deleted). It also reverses Align and Distribute actions. The **Undo** is only active at the hierarchical level where the **Cut**, **Clear**, **Align**, or **Distribute** occurred. A maximum of 10 **Undo** actions can be active at any one time. As editing events occur that create **Undo** actions, the most recent 10 actions are the ones that are kept. The **Undo** menu and the tool tip for the **Undo** button will update to show the next **Undo** action (**Undo Clear**, **Undo Cut**, **Undo Align**, **Undo Distribute**). **Undo** actions are active in the reverse order of the editing actions that created them. For instance, if Activities are aligned, then an Activity is deleted, the order of **Undo** actions would be **Undo Clear** followed by **Undo Align.**

Cut

Cut cuts the selected object from the model layout. The cut object is copied to the clipboard, and the object may be pasted onto a different part of the layout or into another open model using **Edit/Paste**. Connectors and Pads cannot be cut. They can only be cleared.

Copy

Copy places a copy of the selected object in the clipboard. It will remain there until replaced by another object that is cut or copied. Once a copy is made, it can be pasted on the layout or into another model by using the **Edit/Paste** command.

Paste

Paste makes a copy of the object in the clipboard and pastes it onto the layout. Multiple copies of an object can be pasted without additional copies being made. Pasting items into a model different from the model where the copy or cut occurred can cause loss of entity, attribute, resource, function, or distribution references. See "Advantage of Templates Over Copy/Paste" on page 209 for more information.

Duplicate…

Duplicate… is a shortcut that copies a selected object from the layout and then does a paste to a position selected on the layout. This combines **Copy** and **Paste** into one command. This is useful when you want to quickly copy something on the layout and paste it somewhere else.

Clear

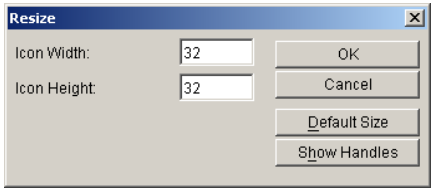
Clear deletes a selected object without copying it to the clipboard.

Select All

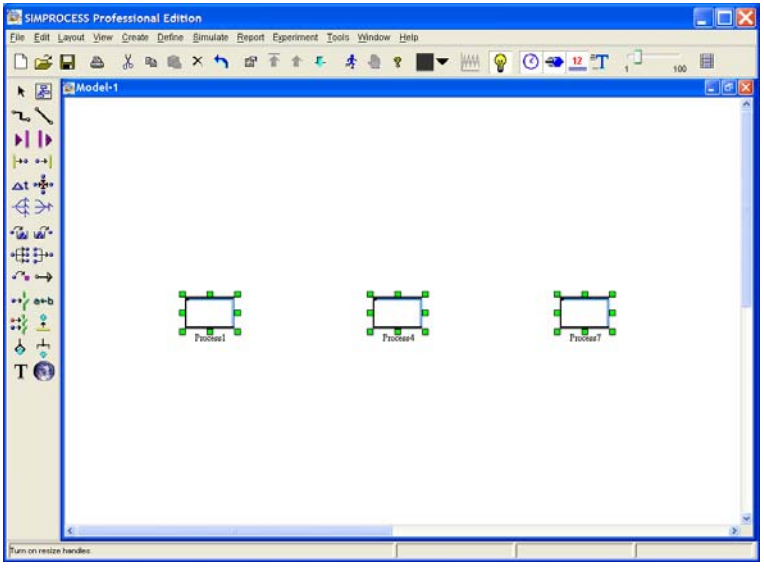
Select All selects all objects on the model layout.

Resize

Resize lets you resize a layout object. You can resize the horizontal and vertical directions separately if you wish to resize the icon in a non-proportional way. The values represent pixels. The **Default Size** button sets the **Icon Width** and **Icon Height** to the default size of the icon. Choose the **Show Handles** button if you would like to drag to resize the object. Multiple objects can be resized at the same time by having multiple items selected when choosing **Resize**. **Important Note**: An object cannot be resized smaller than 10 x 10 pixels. Thus, if numbers are entered that are smaller, the object will be resized to 10 x 10. Also, Background Text objects cannot be resized using **Resize**. The font properties must be changed to resize Background Text.



The following image shows three processes after **Show Handles** was selected.



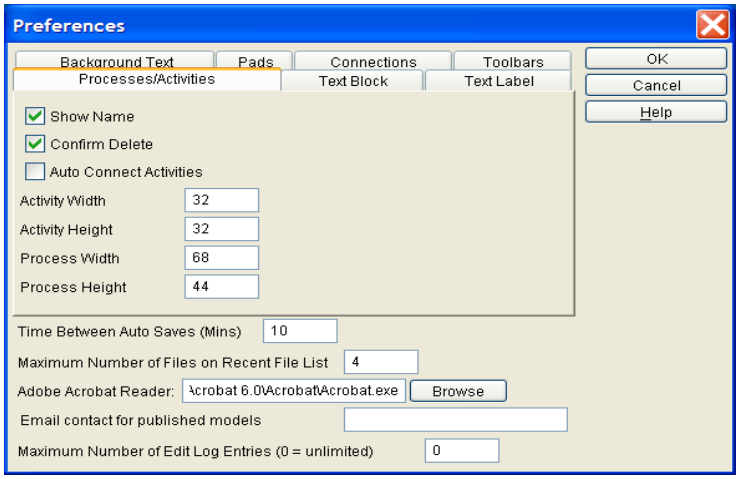
Switch Activity To

Switch Activity To changes an activity from one type to another. This menu item is only displayed when one and only one activity is selected on the layout. Processes do not activate this menu item. Items that are in common between the old activity type and the new activity type are transferred to the new activity. Since some activities allow multiple connections to output pads and some do not, all connections to the old activity may not transfer to the new activity. This menu item also displays on the pop up menu.

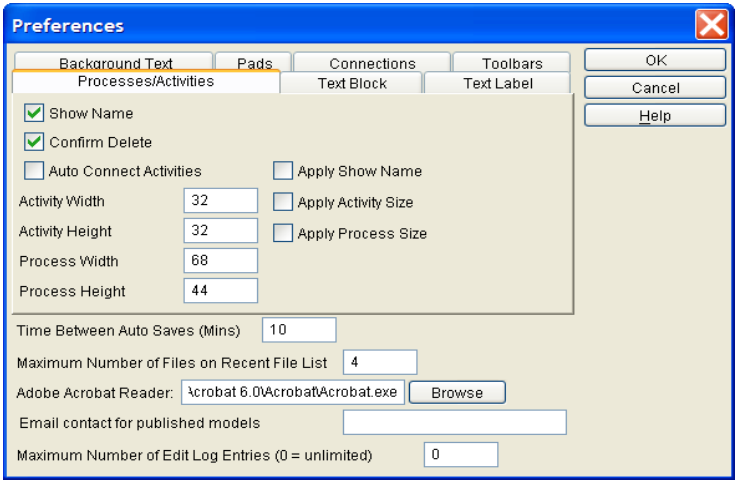
Preferences

Preferences allows the setting of personal preferences for various options in SIMPROCESS. These

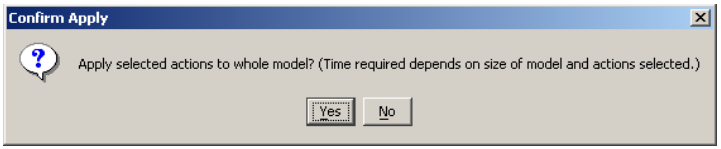
preferences take effect after the dialog is closed.



If a model is open when the **Preferences** menu item is selected, check boxes appear that allow selection of preferences to be applied to the active model.



Preferences selected for application to the active model are applied when **OK** is clicked. Before the selected actions are applied to the active model, a dialog confirming that these actions should occur appears.



If **No** is selected, the active model is not updated. It may take a few minutes to apply updates to a large model. Other editing actions are not allowed while the update occurs. Note that these updates actually change the properties of the active model. The options to display or not display Activity, Pad, and Connection names on the **View** menu do not change the model properties, just what is currently visible. (See page 41.)

There are seven tabs on the Preferences menu:

- Processes/Activities
- Text Block
- Text Label
- Background Text
- Pads
- Connections
- Toolbars

Processes/Activities

Show Name specifies to show the name on the layout by default for newly created Activities.

Confirm Delete causes a confirmation dialog to appear when you delete an Activity or a Process.

Auto Connect Activities causes new activities placed on the layout to automatically connect (if possible) with any previously selected activities. The type of connector to use (**Bent** or **Straight**) is set on the **Connections** tab. This option can also be turned on/off on the pop up menu.

Activity Width/Height sets the default width and height of new Activities.

Process Width/Height sets the default width and height of new Processes.

Text Block

Show Text Block displays the text blocks for the Activities on the layout.

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Text Label

The Text Label preferences are for text labels that are created from the Text Block of a Process. See "Labeling with Text Blocks," beginning on page 60 for information on how to use these.

Horizontal Text Label sets whether the label should be horizontal (selected) or vertical (not selected) on the layout.

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Background Text

The **Font Attributes** set the default **Font Name**, **Size**, **Color**, **Bold** and **Italic**.

Pads

Show Name shows the pad names on the layout.

Confirm Delete causes a confirmation dialog to appear when you delete a Pad.

Pad Size specifies the default size of pads: **Small**, **Medium**, or **Large.**

Connections

Show Name displays Connector names on the layout.

Confirm Delete causes a confirmation dialog to appear when you delete a Connector.

Line Width specifies the default line width for new Connectors.

Line Style specifies the default line style for new Connectors.

Default Connector for Auto Connect specifies the type of connector (**Bent** or **Straight**) to use when **Auto Connect Activities** on the **Processes/Activities** tab is selected.

Toolbars

The display of the Toolbar and Palette is optional.

Other Preferences

Time Between Auto Saves determines the approximate amount of time between automatic saves of the model. The automatic save feature creates a file with the same name as the current model, except with an identifier number added along with the extension .tmp (e.g., MyModel.spm would be saved as MyModel-1.tmp). If the current model is new and has not been saved, the name of the temporary file will be the model's assigned name (Model-1, Model-2, etc.) with a .tmp extension and will be located in the models directory.

NOTE: The automatic save does not affect the `.bck` file. The `.bck` file is created or updated when you initiate a save. See page 19 for information on the backup file.

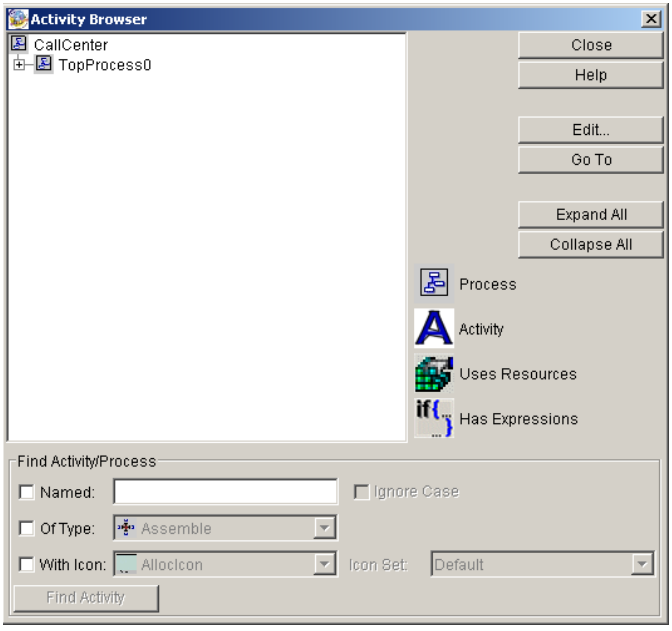
Maximum Number of Files on Recent File List defaults to 4. Sets the number of files on the **File** menu. The allowable values are 0 through 9.

Adobe Acrobat Reader sets the location of Acrobat Reader for the documentation.

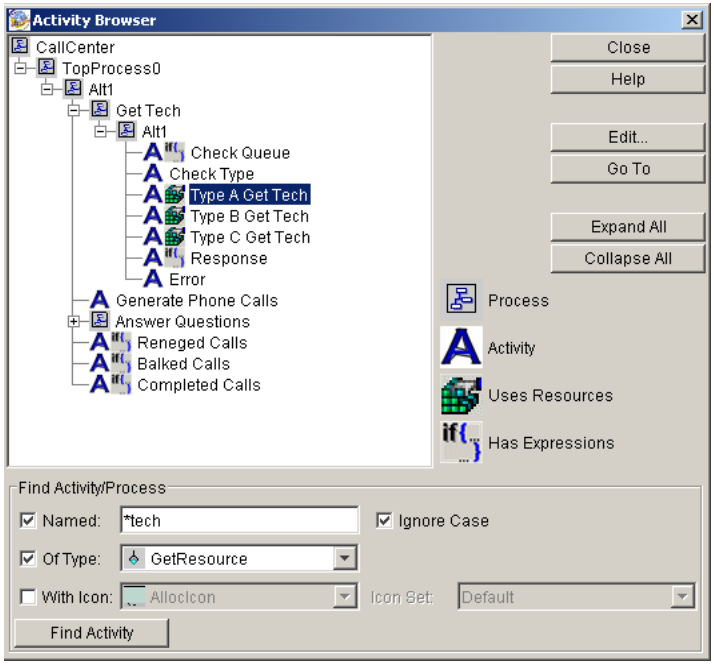
Maximum Number of Edit Log Entries sets the limit of entries in the model's edit log. The default is unlimited (0 entry).

Activity Browser...

Activity Browser... is a feature for navigating among the Activities. A dialog lists all the Activities and Processes contained in the model. Any name preceded by a (+) signifies a hierarchical Process or a Process Alternative. Double-clicking on the Process or Process Alternative name will expand the tree diagram, displaying Activities and Processes underneath. Double-clicking on the Activity name will bring up the properties of the Activity. Each item has an icon that identifies the item as an Activity or a Process, and an icon that indicates whether the item has Expressions or Resources. Select an Activity and either **Edit** the Properties of that Activity or **Go To** the layer in the model layout where that Activity resides. **Expand All** expands the complete model hierarchy, and **Collapse All** restores the hierarchy to the top level.

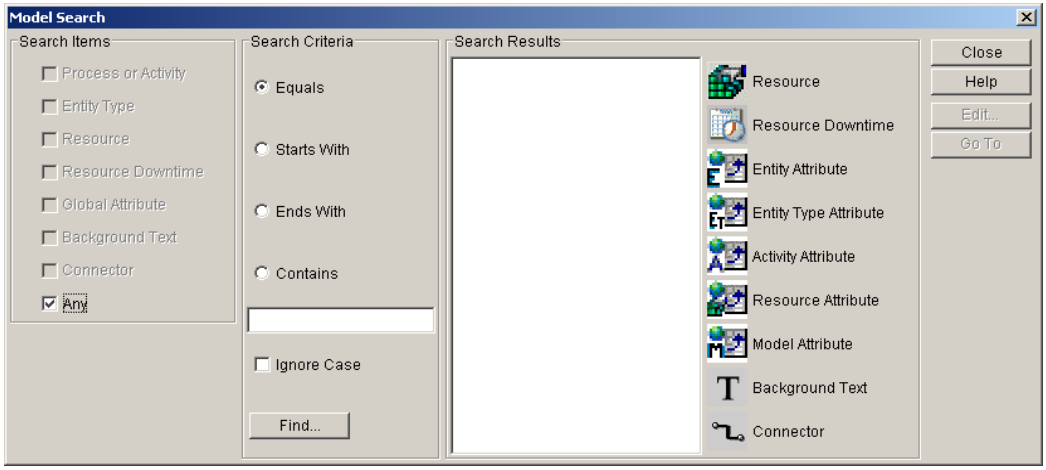


The Activity Browser can be used to search for specific Processes or Activities. There are three search criteria: Activity name, Activity type, or Activity icon. Each can be used individually or in combination. Search criteria that are combined are combined using “and” logic. The asterisk (*) can be used as a wildcard for name searches. The asterisk can go at the beginning of the search string, the end of the search string, or both. Wildcards cannot be used in the middle of a search string. Select **Ignore Case** to perform case insensitive searches. Selecting **Find Activity** finds the first Activity in the model hierarchy that matches the search criteria. Subsequent clicks of **Find Activity** will continue the search for the next match.

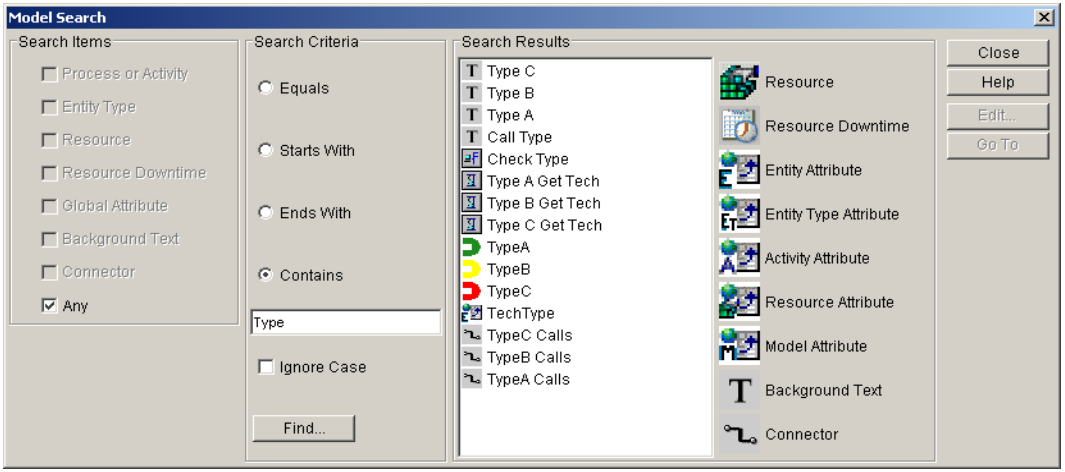


Model Search...

Model Search is a quick way of searching by name for items within the model. The **Model Search** dialog has three areas: **Search Items**, **Search Criteria**, and **Search Results**.



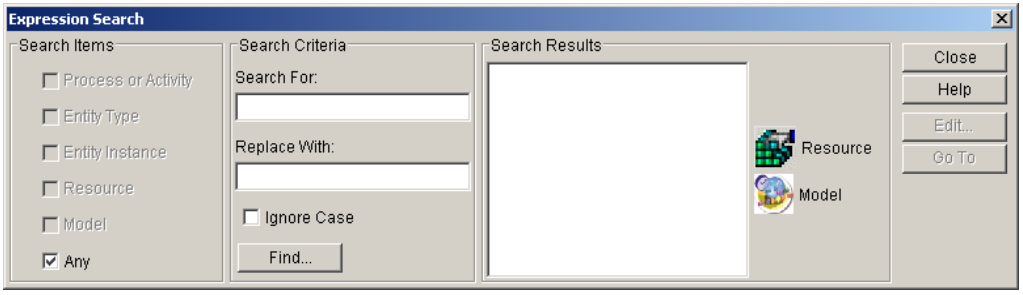
Search Items has eight check boxes: **Process or Activity**, **Entity Type**, **Resource**, **Resource Downtime**, **Global Attribute**, **Background Text**, **Connector**, or **Any** (default). The other items become available for selection when **Any** is deselected. **Model Search** searches the names of the selected **Search Items** based on the options set in **Search Criteria**. Enter the string to search for in the text field of **Search Criteria**, then select how to compare the string entered with the names of the selected **Search Items**. The options are **Equals**, **Starts With**, **Ends With**, or **Contains**. Select **Ignore Case** to perform a case insensitive search. Once the **Search Criteria** has been set, click the **Find...** button to perform the search. **Search Results** displays the items found. The type of each item found (Process or Activity, Entity Type, Resource, Global Attribute, Background Text, or Connector) is identified by an icon to the left of the name. Process, Activity, or Entity Type items display a scaled down version of their assigned icons. Resource, Global Attribute, Background Text, or Connector display an icon based on the legend to the right of the list. The example below shows a search on the `CallCenter.spm` demonstration model. The search was a case sensitive search for any names containing **Type**. Four background text items, four activities, three entity types, one global entity attribute, and three connectors were found.



Selecting an item will cause the **Edit...** button to activate. The properties of the item can be edited by clicking the **Edit...** button or by double-clicking an item. The **Go To** button will activate if the item selected is a Process or Activity. Selecting **Go To** will take you to the level of the model where that item is located.

Expression Search...

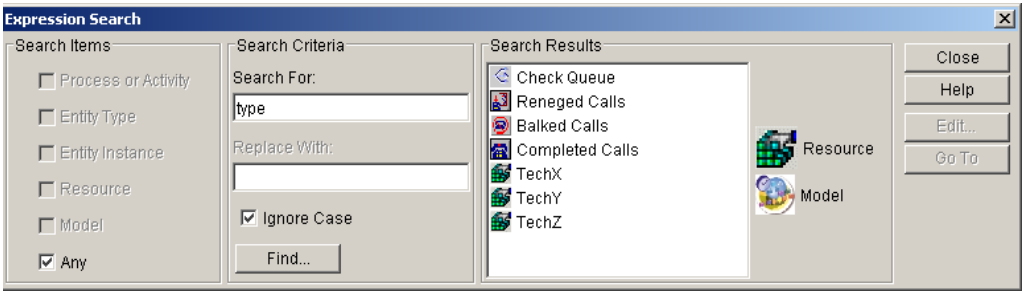
Expression Search is a quick way of searching for the existence of expressions or for expressions that contain specific text. Searching for text can also include replacing text. As with **Model Search**, the **Expression Search** dialog has three areas: **Search Items**, **Search Criteria**, and **Search Results**.



Search Items has six check boxes: **Process or Activity**, **Entity Type**, **Entity Instance**, **Resource**, **Model**, or **Any** (default). The other items become available for selection when **Any** is deselected. **Expression Search** searches the expressions of the selected **Search Items** based on the options set in **Search Criteria**. To find items that have expressions no matter what the text of the expressions, leave the **Search For** field

empty. (Note that if the **Search For** field is empty, items that have Expressions stored in files will be located.) To search for specific text in expressions, enter the search text in the **Search For** field. All searches are "contains" searches. That is, there is a match if the text in the **Search For** field is contained within any line of an expression. Select **Ignore Case** to perform a case insensitive search. If the **Replace With** field is not empty, the text in the **Search For** field found in expressions will be replaced with the text in the **Replace With** field. There is no undo for replace actions. Also, replace actions are case sensitive only. Selecting **Ignore Case** will empty and disable the **Replace With** field. Expressions stored in files are not included in searches when the **Search For** field contains text.

Once the **Search Criteria** has been set, click the **Find...** button to perform the search. **Search Results** displays the items found. The type of each item found (Process or Activity, Entity Type, Resource, or Model) is identified by an icon to the left of the name. Process, Activity, or Entity Type items display a scaled down version of their assigned icons. Resource and Model display an icon based on the legend to the right of the list. The example below shows a search on the `CallCenter.spm` demonstration model. The search was a case insensitive search for any expressions containing **type**. Four activities and three resources were found.



Selecting an item will cause the **Edit...** button to activate. The properties of the item can be edited by clicking the **Edit...** button or by double-clicking an item. The **Go To** button will activate if the item selected is a Process or Activity. Selecting **Go To** will take you to the level of the model where that item is located.

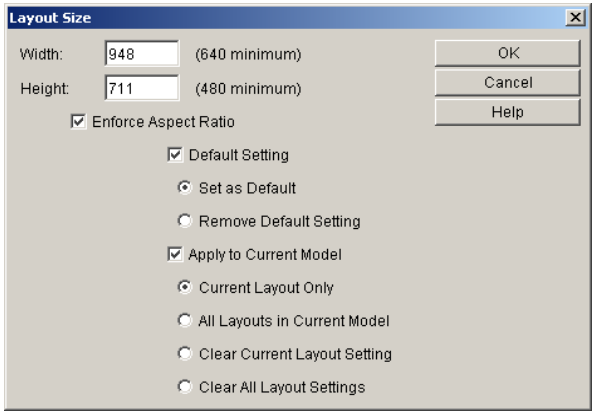
Properties…

Selecting **Edit/Properties...** will bring up the **Properties** dialog box for the selected item. This has the same effect as double-clicking on it. Use this menu item most often when you want to edit Hierarchical Processes, since double-clicking on them will show their internal structure and not bring up their dialog box.

Layout Menu

Size... brings up a dialog that allows you to specify the size (in pixels) used in the drawing of model layouts. The layout is the area on the screen where models are built and displayed. The default setting is a width of 948 and height of 711. The size can be changed for the current session, saved and used for subsequent SIMPROCESS sessions, saved with the current model layout and always used to display it, or saved and used with all layouts in a model. Each time a layout is displayed, its stored size will be used. The session setting will be used if there is not a stored size.

The ratio of height to width is 0.75. This ratio is enforced whenever a change is made to the height or width. If the height were changed to 712, for example, the width would automatically change to 952, and the entered value of 712 would change to 714. Thus, both values are updated to the next higher values that meet the 0.75 ratio. Deselecting **Enforce Aspect Ratio** disables the enforcing of the aspect ratio.



Width is the width of the layout in pixels (640 minimum).

Height is the height of the layout in pixels (480 minimum).

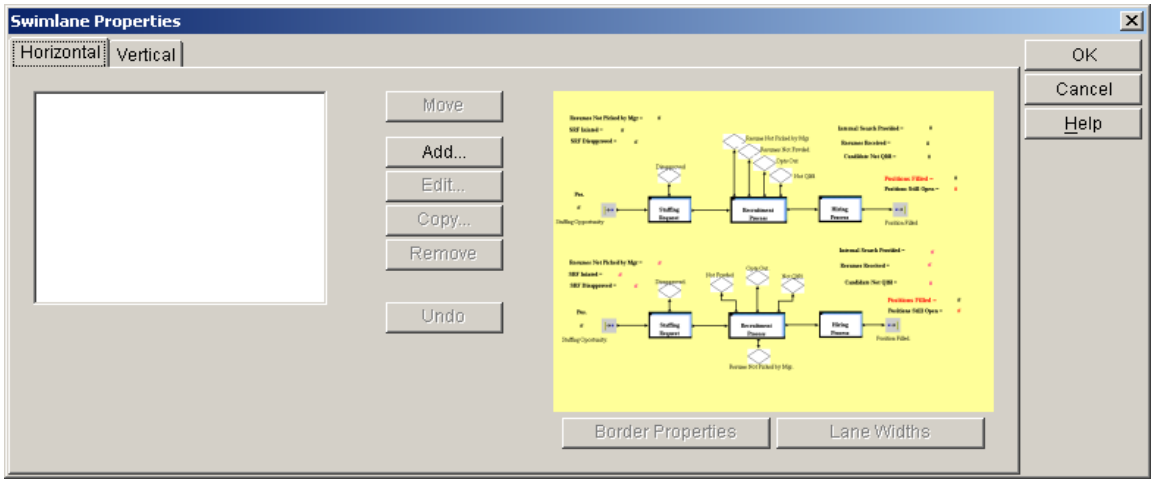
Default Setting either saves the entered width and height as the session default (**Set as Default**) and causes this size to be saved for use in future SIMPROCESS sessions, or it removes the saved session setting (**Remove Default Setting**) so that future SIMPROCESS sessions will use the 948 by 711 size. The setting used for the remainder of the current SIMPROCESS session (unless changed again via this dialog) will be the one specified here.

Apply to Current Model enables the following four options:

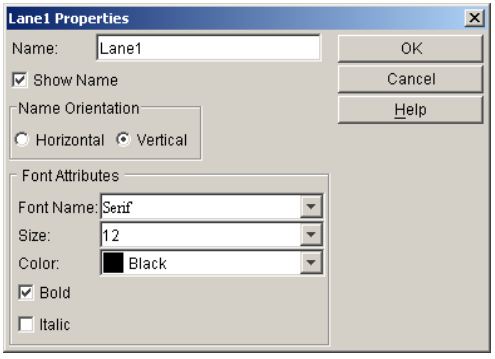
- **Current Layout Only** applies the entered values only to the active layout. The specified size of the current layout will be stored with the model when the model is saved.
- **All Layouts in Current Model** stores the entered values with all layouts in the active model so that they become permanent (if the model is saved).
- **Clear Current Layout Setting** removes a previously specified layout size for the current layout, so that the layout is subsequently redrawn (when necessary) using the current session layout size.
- **Clear All Layout Settings** removes stored layout sizes for all layouts of the current model. The layouts will subsequently display using the current session layout size.

The current session setting is only changed if no checkboxes are selected or if the **Default Setting** checkbox is selected. Each time a layout is displayed, if a layout size is specified in the model, that size will be used; if none is found, the current session setting will be used instead.

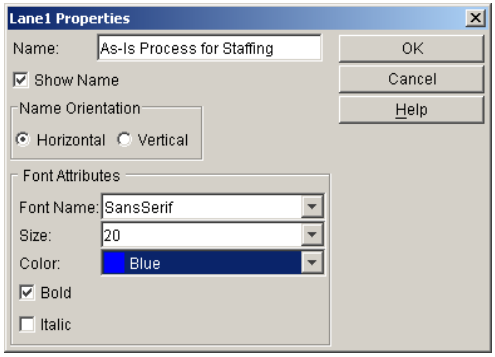
Swimlanes... allows you to add swimlanes to the current layout. The swimlanes dialog has two tabs: **Horizontal** and **Vertical**. On the left side of each tab is the list of swimlanes. The right side has a miniature view of the current layout. Note that more than one lane must be added for anything to appear on the miniature view or on the actual layout. Both horizontal and vertical swimlanes can be on the same layout. The example below shows a modified version of the demonstration model, `Human Resources.spm`.



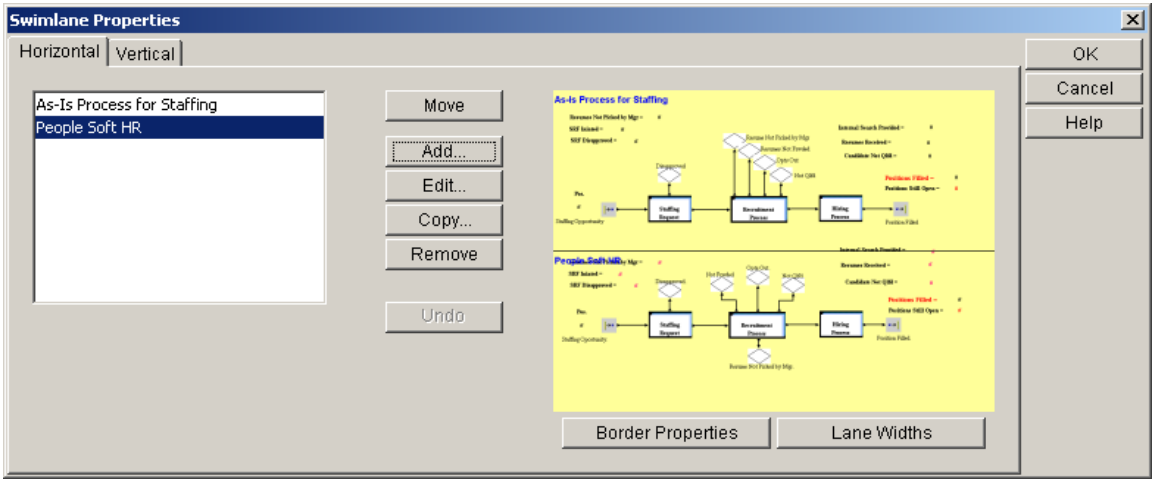
Click the **Add...** button to add a swimlane. This brings up a dialog which contains the name of the swimlane, whether the name should be displayed (**Show Name**), whether the name should be displayed horizontally or vertically (**Name Orientation**, horizontal swimlanes only), and the **Font Attributes** for the name.



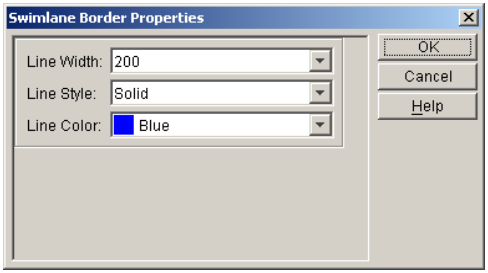
Edit the properties to set the appropriate name and display characteristics.



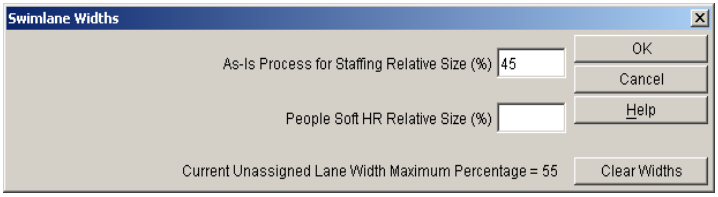
Adding a second swimlane causes a swimlane border to appear in the miniature view. Adding a third swimlane would cause a second swimlane border to appear. There is always one less border than swimlanes. The borders are evenly spaced down (or across for vertical swimlanes) on the layout.



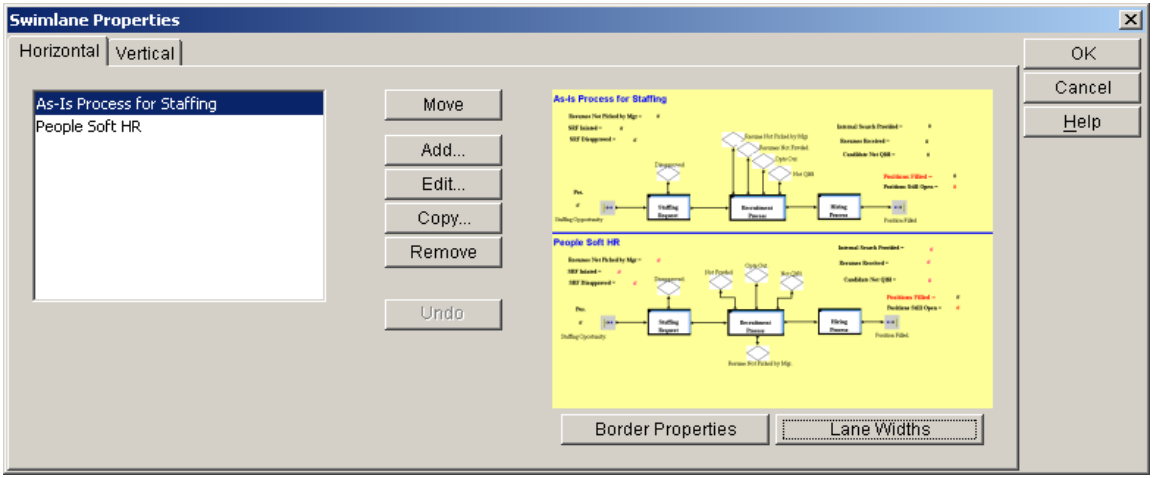
Once there are at least two swimlanes defined, the **Move** button and the two buttons below the miniature view activate. The **Move** button allows the rearrangement of the order of swimlanes without having to delete and recreate. The **Move** button causes the selected item to move down in the list. **Move** causes the item to go to the top of the list if the selected item is the last item. The **Border Properties** and **Lane Widths** buttons change the look of the borders and the widths of the swimlanes. **Border Properties** brings up a dialog that sets the **Line Width**, **Line Style**, and **Line Color** for each of the borders. The properties apply to the borders top to bottom for horizontal swimlanes and left to right for vertical swimlanes. Since there are only two lanes, there is only one border.



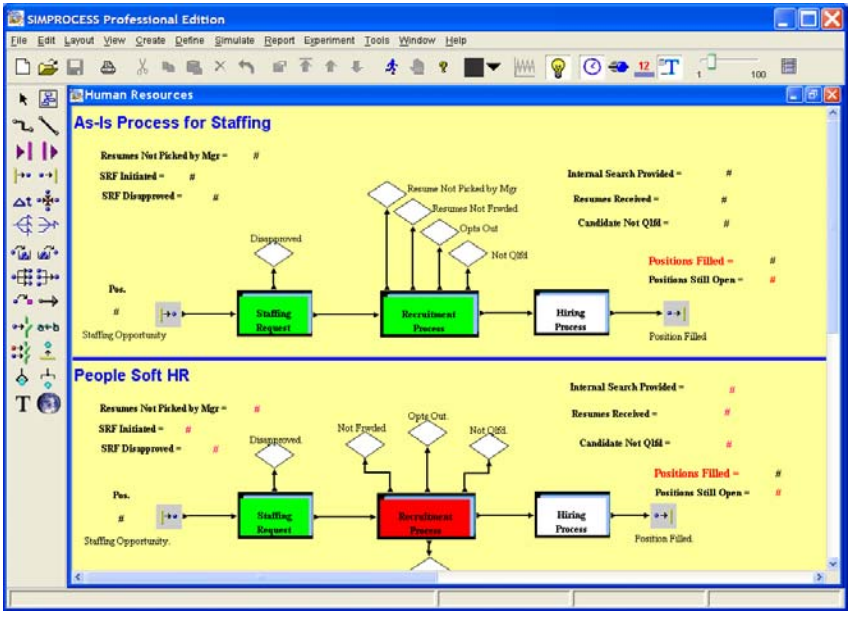
The **Lane Widths** button changes the widths of the swimlanes. The swimlane defaults to evenly spaced widths. Each swimlane will be 50% of the layout if there are two swimlanes. The dialog allows you to enter relative percentages for all or some swimlanes. Entries are not required for each swimlane. The minimum swimlane width is 5% of the layout. Swimlanes that do not have an entry will be evenly spaced across the remaining area of the layout. The **Current Unassigned Lane Width Maximum Percentage** shows the maximum value that can be assigned to a lane. **As-Is Process for Staffing** is assigned 45% of the layout area in the example below. This means 55% of the layout area is left for **People Soft HR**. The **Clear Widths** buttons removes all swimlane width assignments.



For the image below, adjusting the width removes the overlap of the **People Soft HR** swimlane title with the dynamic labels.



When **OK** is selected on the Swimlane Properties dialog, the swimlanes are drawn on the model layout. Note that swimlane borders or titles may not be edited by clicking on the layout. All edits must be done from the Swimlane Properties dialog.

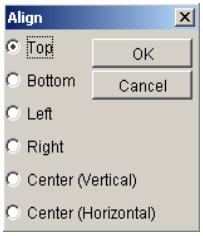


Background Color

Current Layout changes the background color of the visible layout to the selected color.

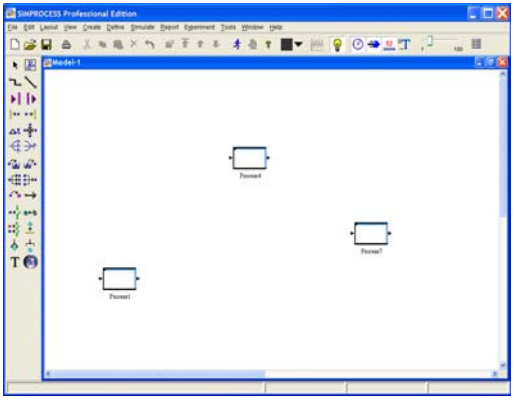
All Layouts changes the background color of all layouts in the active model to the selected color.

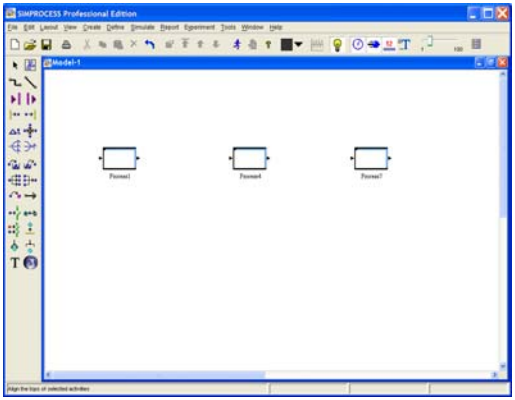
Align…



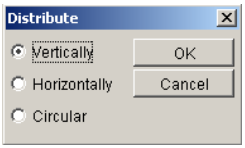
Aligns a number of selected objects according to various criteria.

Top aligns the tops of the selected objects.
Bottom aligns the bottoms of the selected objects.
Left aligns the left sides of the selected objects
Right aligns the right sides of the selected objects
Center (Vertical) aligns the centers of the selected objects along a vertical line.
Center (Horizontal) aligns the centers of the selected objects along a horizontal line.
The screen shots below show the effect of using **Align** before and after aligning the horizontal centers:





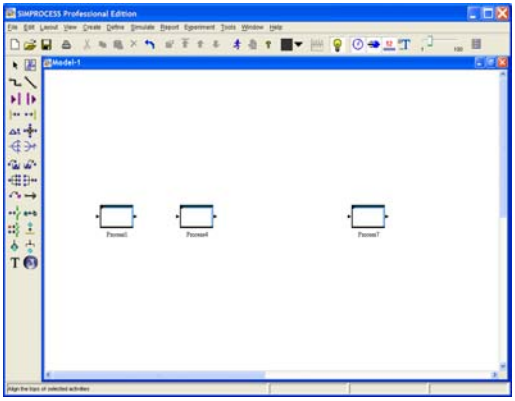
Distribute…



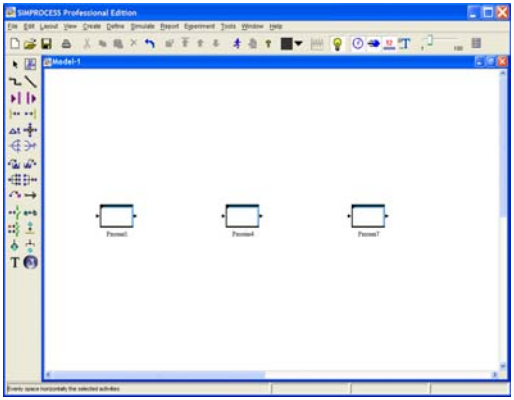
Distributes three or more selected objects so that they are equally spaced, vertically, horizontally, or circularly.

The screen shots below show the results of using **Distribute** on some unequally spaced objects.

Before using **Distribute**:



After using **Distribute**:



Distribute Pads

Pads added to a Hierarchical Process can be spaced evenly by selecting **Distribute Pads.** Although intended for the Hierarchical Process, this menu item can be used for any Activity or Process.

Group combines multiple objects into a *group*. All normal editing operations that can be done on an individual object can be done on the group. This can be useful when the model is divided into logical sections. A section can be grouped and then moved with respect to the other sections. A group can be cut from the layout, or copied and pasted to create an identical group.

Use **Ungroup** to edit individual components of a group.

Ungroup breaks up a group into the original components that went into making the group.

Bring To Front brings an object to the front of the layout so it can be edited.

Send To Back sends an object that is at the front of the model layout to the back.

Snap To Grid. Once turned on, objects can only be placed on the layout at grid intersections.

Grid Lines places a grid on the model layout as a convenience in aligning objects. The grid has no significance to the model.

Grid Spacing changes the spacing of the grid. Three levels are offered: Fine, Medium, and Coarse.

Grid Color changes the color of the grid to the color selected on the color button.

View Menu

Descend takes the model down one level in the model hierarchy.

Ascend takes the model one level up in the Process hierarchy.

Go To Top takes the model to the top of the Process hierarchy.

Activities

Hide hides the selected Activity. The Activity and its Connectors to it will not be visible on the layout.

Show All makes all Activities and their Connectors visible.

Show Attached makes all the Activities that are connected to a selected Activity visible.

By Resource... allows you to view or edit resource Activity assignments.

Resources

By Activity allows you to view or edit resource usage by Activity.

Activity Names. These menu items only affect the display of Activity names. The changes are not saved with the model.

Show All makes all Activity names visible throughout the model.

Hide All makes all Activity names invisible throughout the model.

Local shows or hides Activity names based on their individual properties (set with the **Properties** dialog **Show Name** checkbox). This is the default setting when a model is opened.

Connector Names

These menu items only affect the display of connector names. The changes are not saved with the model.

Show All makes all connector names visible throughout the model.

Hide All makes all connector names invisible throughout the model.

Local shows or hides connector names based on their individual properties (set with the **Properties** dialog **Show Name** checkbox). This is the default setting when a model is opened.

Pad Names

These menu items only affect the display of Pad names. The changes are not saved with the model.

Show All makes all Pad names visible throughout the model.

Hide All makes all Pad names invisible throughout the model.

Local shows or hides Pad names based on their individual properties (set with the properties dialog **Show Name** checkbox). This is the default setting when a model is opened.

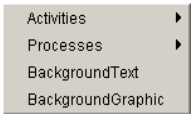
Zoom In magnifies a section of the layout to see more detail. Select **Zoom In** and click and drag the mouse to define the area on the layout to zoom.

Zoom Out is the reverse of **Zoom In**.

View (1:1) returns the layout window to its original size.

Refresh redraws the current screen.

Create Menu



Activities provides an alternative way of creating Activities, rather than graphically dragging and dropping them from the palette.

Activities added to a library will be added to this menu even if they are not added to the palette.

Processes provides an alternative way of creating Processes.

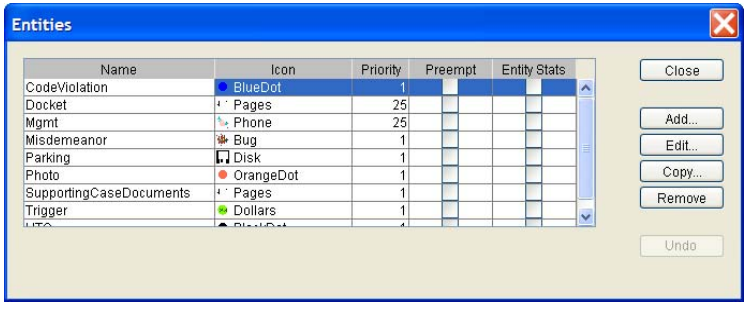
Processes added to a library will be added to this menu.

BackgroundText provides an alternative way of creating static or dynamic labels.

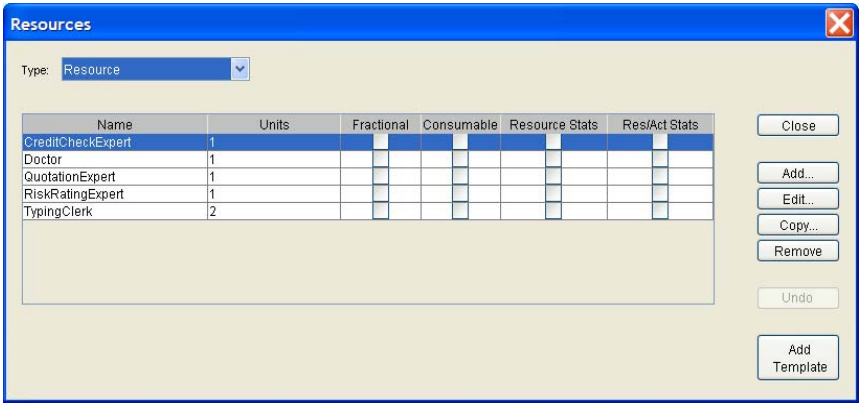
BackgroundGraphic provides an alternative way of changing the background.

Define Menu

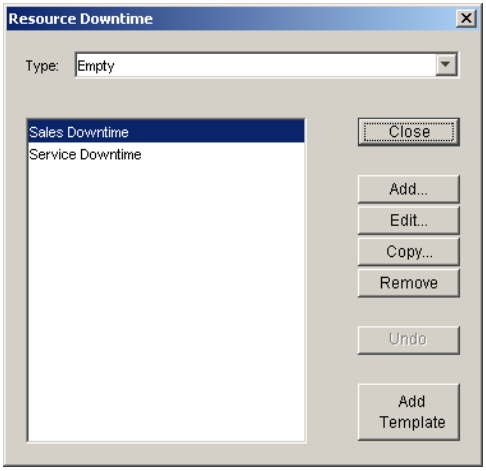
Entities... is used for managing Entity Types in the model.



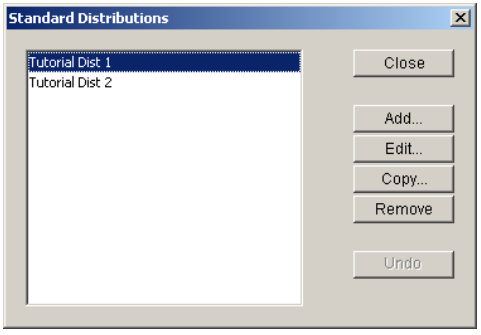
Resources... is used for managing Resources in the model.



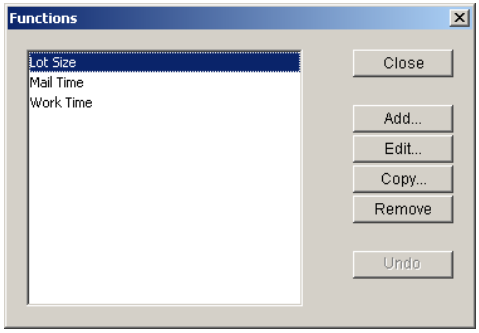
Resource Downtimes... is used for managing Resource Downtimes in the model.



Distributions is used for managing customized **Standard** and **Tabular Distributions**. Once a Distribution is defined, it can be used throughout the model without the need to redefine the parameters of the distribution.



Functions... is used for managing **Functions**. Mathematical functions defined here can be used throughout the model.

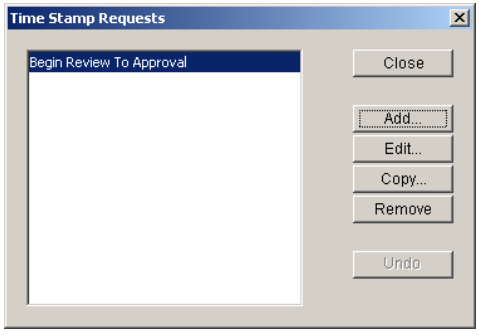


Seeds... is used for viewing the random number stream seeds.

Global Attributes... is used for globally defining attributes for **Entity** instances, **Entity Types**, **Resources**, **Activities**, and the **Model**. See "Introduction to Attributes and Expressions," beginning on page 212 for more information on Attributes.

Model Expressions... defines customized Processing for the model at various points during a simulation. This topic is covered in detail in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 210.

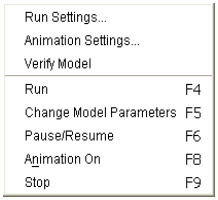
Time Stamps... manages **Time Stamps**. **Time Stamps** can be used as event logs. (See "Event Logs" on page 309.)



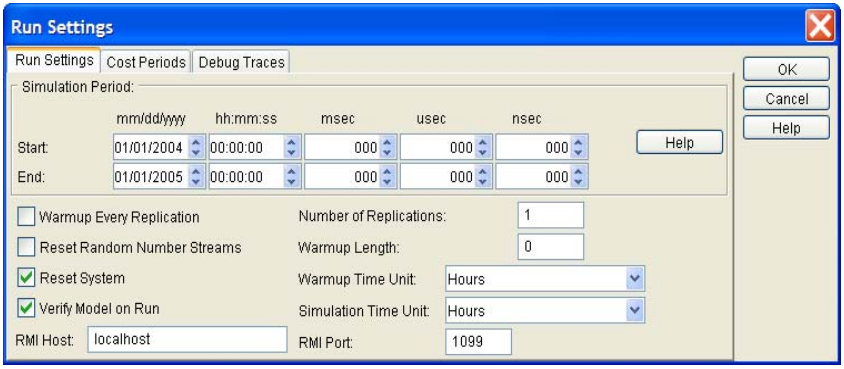
Templates defines and edits **Templates**. This option also allows saving templates to a library or loading a new library. See Chapter 9, "Reusable Templates and Libraries," beginning on page 197.

Model Description... provides a place to document the model. See "document Subdirectory" on page 422 for information on customizing the headings.

Simulate Menu



Run Settings…

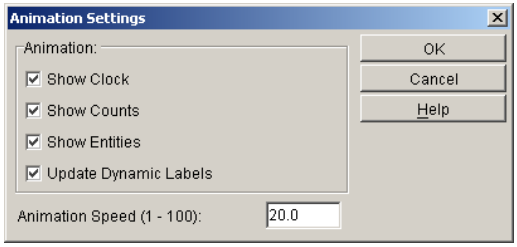


Run Settings tab is used to set the run options for the simulation. (See “Run Settings” on page 90.)

Cost Periods tab defines cost periods for Activity based costing calculations. (See “Setting Up Cost Periods” on page 156.)

Debug Traces tab defines trace files of entity actions for debugging purposes. (See “Debug Traces” on page 92.)

Animation Settings…



Show Clock turns the simulation time clock on or off while the simulation is running.

Show Counts. If **Show Counts** is turned on, each Activity or Process will display a number above its icon.

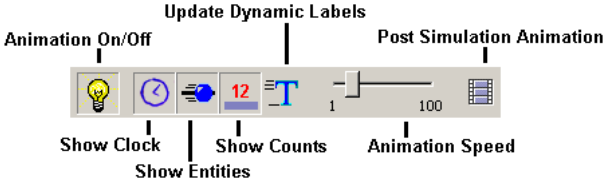
- Generate Activities show the number of Entities generated.
- Dispose Activities show how many Entities have been disposed.
- All other Activities and Processes show how many entities are in that Process or Activity.

Show Entities turns the display of Entities on or off during the animation. Showing Entities assists with visualizing the workflow.

Update Dynamic Labels turns the display of dynamic labels on or off during the animation.

Animation Speed. Changes the **Animation Speed** during the simulation. The fastest value is 100, and the default is 20. A smaller value is better while debugging the model.

The animation setting can also be changed by using the buttons and slider on the tool bar. A depressed button means the item represented by the button is turned on. Going from left to right, the buttons are **Animation On**, **Show Clock**, **Show Entities**, **Show Counts**, and **UpdateDynamicLabels**. The slider is for **Animation Speed**. The final button displays the post simulation animation controls. (See “Post Simulation Animation” on page 149.)



Run

Run verifies the model (if selected) and then starts the simulation running.

Change Model Parameters

This item, available only while running a model which has attributes identified as Model Parameters, will pause the simulation and allow parameter values to be changed. See "Running a Simulation with Model Parameters," beginning on page 80 for more information on Model Parameters.

Pause/Resume

If the simulation is running, it pauses the simulation. If the simulation is paused, it resumes running the simulation.

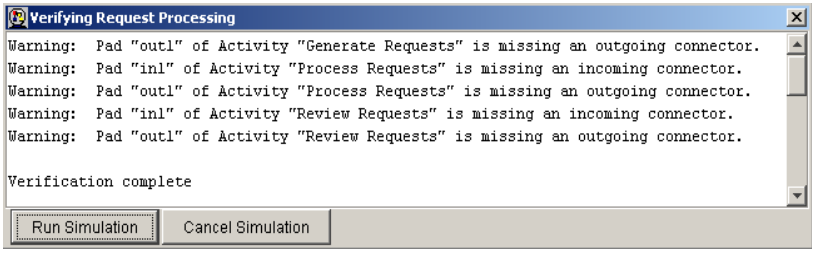
Stop stops the simulation and ends the collection of statistics.

Animation On

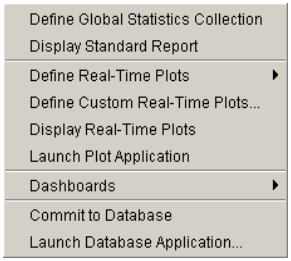
Animation On turns animation on or off, but does not turn on animation that is turned off in the **Animation Settings**.

Verify Model

Verify Model checks the model to see whether or not all the Activities are connected properly and if the model can be simulated. If this option is selected in the **Run Settings**, verification is done automatically when a simulation starts. A notification of any problems found will be displayed along with an option to stop the simulation.


Verifying Request Processing
Warning: Pad "outl" of Activity "Generate Requests" is missing an outgoing connector.
Warning: Pad "inl" of Activity "Process Requests" is missing an incoming connector.
Warning: Pad "outl" of Activity "Process Requests" is missing an outgoing connector.
Warning: Pad "inl" of Activity "Review Requests" is missing an incoming connector.
Warning: Pad "outl" of Activity "Review Requests" is missing an outgoing connector.
Verification complete
Run Simulation
Cancel Simulation

Report Menu



Define Global Statistics Collection sets which statistics are collected during the model execution. See "Default Performance Measures" on page 163.

Display Standard Report views reports that contain the statistical results of the simulation run. See "Standard Report" on page 163.

Define Real-Time Plots sets which real-time plots to display during or after the simulation run. See "Defining Plots" on page 176.

Define Custom Real-Time Plots creates plots with multiple values to view during or after the simulation run. See "Custom Plots" on page 185.

Display Real-Time Plots selects real-time plots for viewing. See "Displaying Real-Time Plots" on page 179.

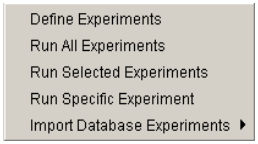
Launch Plot Application opens a blank plot window. Saved plots may then be opened for viewing. See "Displaying Plots Remotely" on page 180.

Dashboards Defines new dashboards for use with models, or **Assigns** previously defined dashboards to a model. See "SIMPROCESS Dashboards" on page 379.

Commit to Database saves simulation results in the SIMPROCESS database (SimProcDB). Commit to Database is described in detail in Chapter 13–SIMPROCESS Database, on page 322.

Launch Database Application starts the database application from within SIMPROCESS. The Manage Results form launches automatically when launching MS Access from this menu item. The Manage Results form is described in detail in Chapter 13–SIMPROCESS Database, on page 322.

Experiment Menu



Define Experiments sets up the experiments to run. The experiments are stored in the file `Experiments.xml`. Defining Experiments is described in detail in Chapter 14–Experiment Manager, on page 334.

Run All Experiments attempts to run every experiment defined.

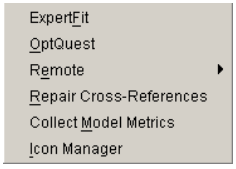
Run Selected Experiments attempts to run experiments for which the **Selected** field is checked.

Run Specific Experiment enters an experiment name that SIMPROCESS will attempt to run.

Running experiments is described in detail in Chapter 14–Experiment Manager, on page 334.

Import Database Experiments imports experiments from the SIMPROCESS database to `Experiments.xml`. (Earlier versions of the SIMPROCESS database allowed defining of experiments within the database.) All experiments, selected experiments, or a specific experiment can be imported. Importing experiments is described in detail in Chapter 14–Experiment Manager, on page 334.

Tools Menu



ExpertFit executes ***ExpertFit***, a data analysis application from Averill Law & Associates, which can be used to analyze data to determine the best standard statistical distribution fit.

OptQuest executes OptQuest optimization from OptTek. See Chapter 15–OptQuest for SIMPROCESS, beginning on page 349 for more information.

Remote has four submenus.

- **Start Local Dashboard Server** starts the Dashboard Server to run Dashboards locally. See "Displaying Dashboards" on page 395.
- **Start RMI Registry** starts the Java RMI Registry. **Start SPServer** will not activate until the Java RMI Registry has been started.
- **Start SPServer** starts SPServer. SPServer must be started for External schedules to operate. See "Adding an External Schedule" on page 286.
- **Stop SPServer** stops SPServer.

Repair Cross-References. Cross references are used in SIMPROCESS models to track Entities, Resources, and Attributes so items cannot be deleted that are in use. Models developed in releases 3.0 through 3.1.1 could have invalid cross references. Recommend running this utility on models developed in release 3.0 through release 3.1.1. The action is applied to the active model.

Collect Model Metrics displays a list of metrics for the active model. The metrics can be saved to a file. Metrics include

Model Name

Number of each type of Activity (Delay, Generate, etc.)

Number of Process Alternatives

Number of Entities, Resources, and Plots

Number of each type of Expression

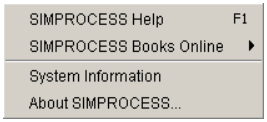
Number of each type of Attribute

Icon Manager is used to import, export, and manage image files. A single image file can be imported for use as an icon, or multiple files (such as a directory of image files) can be imported. See "Importing Graphics Image Files" on page 146.

Window Menu

Displays a list of open models. Allows you to change which model is active.

Help Menu



SIMPROCESS Help displays a list of main help topics.

SIMPROCESS Books Online opens the *SIMPROCESS Getting Started Manual*, the *SIMPROCESS User's Manual*, and the *ExpertFit for SIMPROCESS User's Guide*. This is the complete documentation set for SIMPROCESS.

System Information displays a dialog that lists the relevant system information. It also includes a **Run GC** button. This button calls Java garbage collection and updates the Java memory information.

About SIMPROCESS displays information about SIMPROCESS, including the version, the copyright, and technical support information.

CHAPTER 2

SIMPROCESS Basics

A SIMPROCESS model contains the following components:

- Processes
- Activities
- Entities
- Resources
- Connectors
- Pads

Processes and ***Activities*** represent business operations in a SIMPROCESS model. SIMPROCESS models can be arranged in a hierarchy, with Processes encompassing other Processes and Activities.

Processes

A set of ***Processes*** can represent the operation of a business at a very high level. This level represents only an outline of the business Process.

Activities represent the details of business operations. For example, in a mail order

fulfillment operation, when a customer order is received, processing steps might include:

1. Identifying the customer.
2. Creating or accessing a customer profile.
3. Verifying the customer profile against information contained in the customer's order.

Each of these steps can be modeled as an Activity. Collectively, they comprise a single Process that might be called "Access/Create Customer Profile."

The Process construct allows a business Process to be broken down into successively more detailed layers.

A Process can be (and usually is) composed of other Processes and Activities. Activities cannot be decomposed.

Activities

SIMPROCESS contains a suite of ***Activities***, each reflecting a different type of action. Actions can be physical or logical.

Entities

Entities are objects that circulate through the model. They represent things (e.g., parts, deliveries, people) and information (orders, service requests, etc.) that flow from Activity to Activity. The customer order is an Entity in the order fulfillment process.

Unlike Processes and Activities, which appear as icons in the model layout, Entities aren't visible until a simulation is run. During the simulation, they emerge as icons flowing through the model, if animation is turned on.

Resources

Resources are the agents that add value to Entities or perform work at Activities. Examples include:

- A customer calls in an order, which requires a clerk to handle it. Order entry is the Activity, the order is an Entity, and the clerk is a Resource.
- A truck is required to deliver merchandise to the customer; the truck is a Resource.

The way to minimize cycle time and Activity costs is by experimenting with different levels of Resources and different costs.

The availability of a Resource affects the amount of time it takes an Entity to flow through the Process. Lack of Resources can be a cause of bottlenecks in a business Process. A customer order might arrive while two clerks are busy handling other tasks. Order fulfillment is delayed until a clerk becomes available. The amount of time the customer order spends waiting for an available clerk is shown in the Entity Cycle Time by State output report as Wait for Resource. Another way to describe this situation is that the order waited in a queue for the available Resource.

Knowing how Resources are used is a key factor in understanding and improving upon the way a business operates.

Connectors

Connectors link Activities and Processes together and are the paths used by Entities to flow through the model.

Pads

Pads are small triangular objects attached to Activities and Processes which serve as attachment points for Connectors. A single Pad can connect one or (possibly) more Connectors. Entities flow in one direction, entering nodes at input Pads and exiting at output Pads. Three sizes of Pads are available: small, medium, and large. The Pad size can be changed on the Pad properties dialog, or by right clicking on the Pad and choosing **Pad Size**. The size of all the Pads on an Activity or selected Activities can be changed by right clicking on a selected Activity and choosing **Pad Size**.

Pads also connect one level of a Process hierarchy to another. Pads can be queueing areas for Entities waiting for a Resource or condition.

Putting it Together

A SIMPROCESS model shows a business Process as a set of Nodes (Processes and Activities) connected by Connectors. Entities are generated from one or more Generate Activities, traverse the model, and finally proceed to a Dispose Activity, where they are disposed. Entities pass through other Activities, such as Delays and Branches.

A model is built by supplying numeric and symbolic attributes to the various Activities and the Entities that are processed at these Activities. The Resources needed to process the Entities are also defined.

The end result is a dynamic model of the business Process. Bottlenecks can be seen as they occur when simulations are run on this model. Reports and statistics may be generated describing the flow of people, materials, and information and quantifying how Resources are used. The model may continue to be modified in order to experiment with different scenarios.

A simple model can be built with just three Activity objects: Generate, Delay, and Dispose.

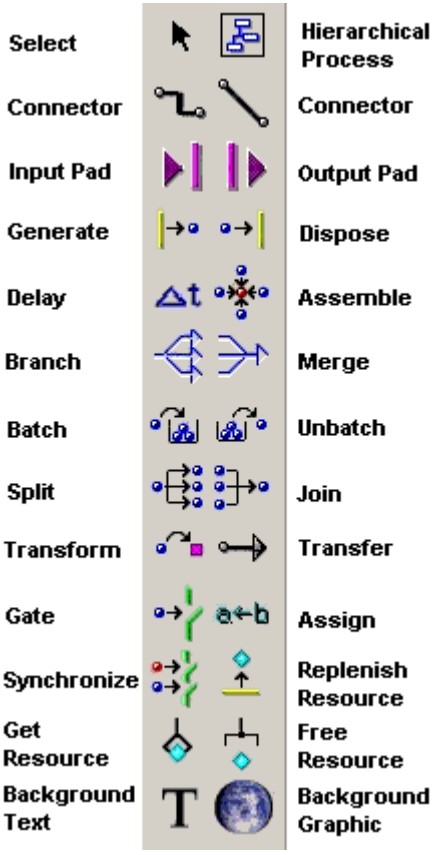
All models require a Generate Activity to generate Entities and a Dispose Activity to end the processing of Entities. Delay Activities are used to represent actions.

There are some things that are common to most Activities, such as the Activity name and Resources required by the Activity. This chapter begins with a discussion of the input fields and command buttons used to define these items. The remainder of the chapter describes the core SIMPROCESS Activities in detail, with particular attention devoted to the Generate Activity and the Entities.

The remaining SIMPROCESS Activities are described in Chapter 4–Activity Modeling Constructs, beginning on page 94, and in “Explicitly Getting and Freeing Resources” on page 133.

Using the Palette Bar to Create Activities

The Palette bar is the two columns of buttons running down the left margin of the SIMPROCESS window. These buttons are used to place model building blocks on the SIMPROCESS layout — the central region of the SIMPROCESS window.



Begin by adding a Generate Activity to the model. Click once on the Generate Activity Palette bar button.

Next, point and click on the SIMPROCESS layout. A Generate Activity icon is added at that location.

Press and hold the **Shift** key while clicking on the layout to add several activities of the same type, i.e., Generate. Each time the layout is clicked, a Generate icon is added to the layout. Release the

Shift key before dropping the last icon or click once on the Select tool to deactivate the Generate button.

Removing Objects from the Layout

Select an object such as an Activity icon from the layout and press the **Delete** key. Several items may be removed at one time by drawing a rectangle around the objects and pressing **Delete** or selecting **Edit/Clear** from the menu or the popup menu.

Common Activity Input Fields

Activity Properties dialogs have the following common input fields:

- **Name** is the name chosen to identify the Activity. This name appears below the Activity, and it can be moved on the layout.
- **Icon** identifies the graphic icon representing the Activity.
- **Comment** is a one-line comment about the Activity. This comment appears in the status bar when the Activity is selected.
- **Documentation** tab contains a **Document** button that opens an edit window for adding descriptive text about the Activity. See "document Subdirectory" on page 422 for information on customizing headings. Also, this tab contains a field for adding a link to a URL or another document. The link is active only for models that have been published to HTML. (See "Export" on page 20.)
- **Attributes** define custom attributes that the Activity requires. This topic is covered extensively in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 210.
- **Expressions** allow customized processing for the Activity at various points during a simulation. This topic is covered in detail in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 210.
- **Event Logs** are used for defining timestamps and recorders.
- **Text Block** is a three-line description that appears within the Activity's icon on the layout.
- **Help** displays information about the Activity.

The following tabs and fields are found on most Activity Properties dialogs:

- **Resources** defines the Resources required to process Entities arriving at the Activity. The Entity waits in a queue until the Resource or Resources can be obtained.
- **Duration/Value** is the amount of time it takes the Activity to process an Entity, once the required Resources are obtained. Time can be defined as a constant, or as a statistical distribution.
- **Duration/Time Units** specifies the units and measure for duration time in nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

The following buttons are found on all Activity Properties dialogs except Background Text. These buttons allow the creation of items that are then available throughout the model.

- **New Entity** creates new Entity types.
- **New Resource** creates new Resource types.
- **Entity** creates new global Entity instance attributes.
- **Entity Type** creates new global Entity Type attributes.
- **Resource** creates new global Resource attributes.
- **Model** creates new Model attributes.

Attributes are covered extensively in Chapter 10, “Customizing a Model with Attributes and Expressions,” beginning on page 210.

Naming Activities

Use the **Name** field to assign a name to an Activity. This name is shown below the Activity icon in the model if the **Show Name** checkbox is selected.

SIMPROCESS assigns new Activities a default name. It is a good idea to change this to a name that is meaningful; one that indicates what occurs at this Activity. Activities can be named just about anything, as long as the same name is not used twice in the same level of the model hierarchy.

Change the name of an existing Activity by clicking in the **Name** field and typing the new name.

The contents of the **Text Block** can be used as the **Name** by selecting the **Use Text Block** check box. The lines of text are appended together with a space between each line to create the **Name**. When **Use Text Block** is selected, the **Name** field is not editable. The values on the **Text Block** tab must be changed to change the **Name**.

Choosing an Icon

The **Icon** field identifies the graphical icon used to represent the Activity in the model layout. All Activity icons are arranged into sets. The set consists of predefined sets and user defined sets. (See “Importing Graphics Image Files” on page 146.) The **Icon Set** field lists the sets of icons available. The set **All** lists all icons regardless of set. Every Activity has several icons from which to choose. The names of the standard icons differ slightly for each Activity, because they include the name of the Activity.

Point and click on and icon’s name to select it. The icon button on the right gives a reduced view of the icon. Click the icon button to see the actual size. GIF, JPG, and PNG files may be imported and used as custom icons for Activities.

Adding a Comment

Use the **Comment** field to add a brief comment describing the purpose of this Activity. This field is optional. Printing **Process Documentation** or **Model Documentation** will include comment in the document. The comment will appear on the status bar when an Activity is selected.

Documenting the Activity

The **Document** button opens an editor in which descriptive information may be added about the Activity. The editor opens with a preformatted template which is changeable. (See “document Subdirectory” on page 422.) Print **Document** text using the SIMPROCESS Print facility.

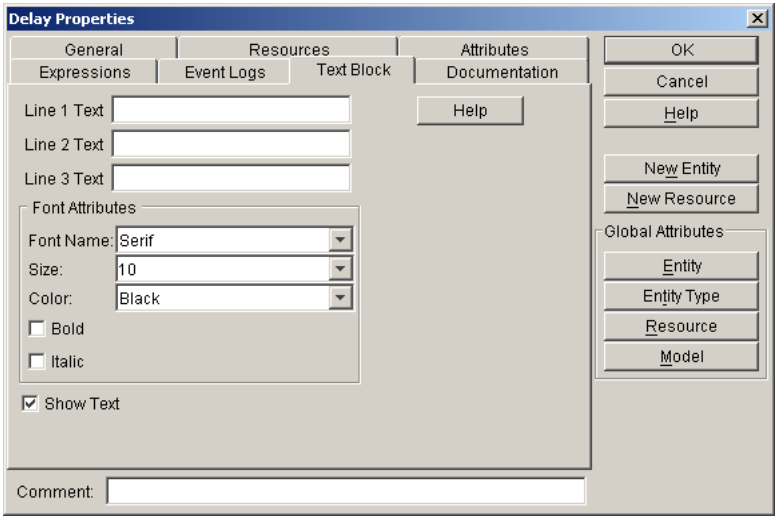
Labeling with Text Blocks

The Text Block tab adds up to three lines of text to the inside of the icon on the layout.

Text Block labels facilitate understanding of the Activity or Process in relation to the model.

Add descriptive labels to an icon by performing the following tasks:

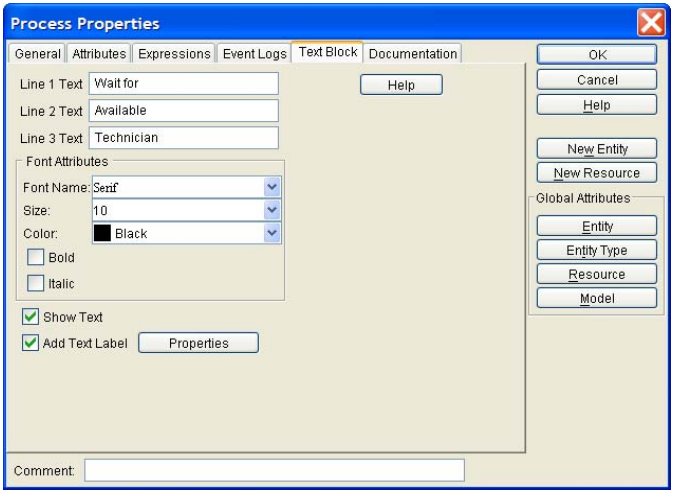
1. Click on Text Block tab:



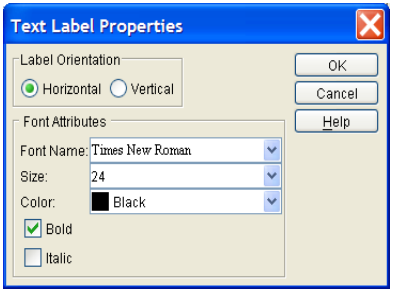
2. Fill in one to three lines of text.
3. Set the desired font attributes.
4. *Make sure the* **Show Text Box** *is checked*. The text entered is not displayed in the model unless this box is not checked.
5. Click on **OK**.

Note: The **Text Block** is best used with blank box icons. Icons with a picture on them will not show the **Text Block** properly.

Process properties include an additional option on the **Text Block** tab. The **Add Text Label** check box places a label that contains the text of the **Text Block** inside each alternative of the Process.



The lines of text are appended together with a space between each line to create the label. Select the **Properties** button to set whether the label should be displayed horizonally or vertically and to set the **Font Attributes** of the label.



The label will be centered across the top of the layout when **Horizontal** is selected, and the label will be centered along the left of the layout when **Vertical** is selected. Note that the labels cannot be resized or moved. Changes can only be made from the **Text Block** tab of the Process properties dialog. Defaults for **Horizontal** or **Vertical** and the **Font Attributes** can be set on the **Text Label** tab of the Preferences dialog (**Edit/Preferences**).

Getting Help

The Help button displays information about the purpose of the Activity and the fields and buttons on the **General** tab of the dialog. The other tabs have Help buttons that are specific to that tab.

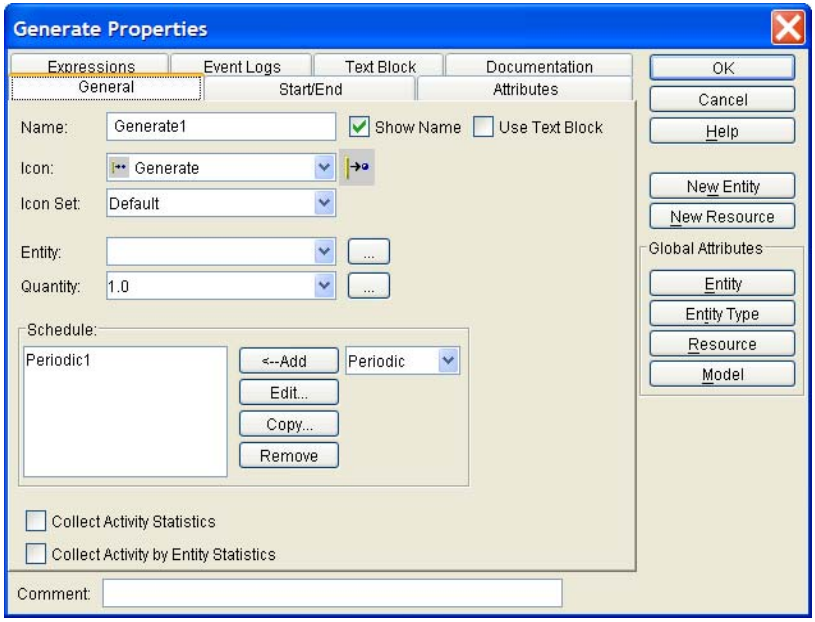
Generate Activity

Generate Activities create Entities for a model during a SIMPROCESS simulation. Generally, the first Activity defined in the model is a Generate.

SIMPROCESS generates Entities at the rate defined in the Generate Activity. Entities can be generated at a constant number and rate, such as a specified interval of time, or according to a statistical distribution. The schedule of generation can be as simple as one constant rate, or as complex as dozens of different rates depending on the hour of the day, day of the week, season of the year, etc.

A Generate Activity can generate one or more types of Entities

Defining a Basic Generate Activity



Click on the **Entity** pull-down arrow to select the default type of Entity to be generated by this Generate Activity. The default Entity type can be overridden in each schedule.

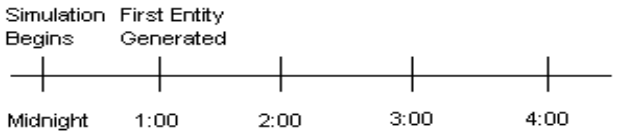
Entities may be defined using the **New Entity** command button on this dialog.

Use the **Quantity** field to specify the default number of Entities to be generated each time Entities

are released. A specific number or probability distribution can be entered in the **Quantity** field or a selection may be made from the **Quantity** pull-down list. The default quantity can be overridden in each schedule.

A periodic schedule is the default schedule. The periodic schedule sets the interval and the time unit. It will default to an interval of 1.0 and time unit of Hours. These defaults can be changed by selecting the schedule (Periodic1) and choosing **Edit**. Change the name of the schedule, override the default Entity type and quantity, and set the interval and time unit with this method.

The **Interval** field defines the time between Entity generation events. Enter a constant value or a statistical distribution. Entities are generated at the end of each interval:



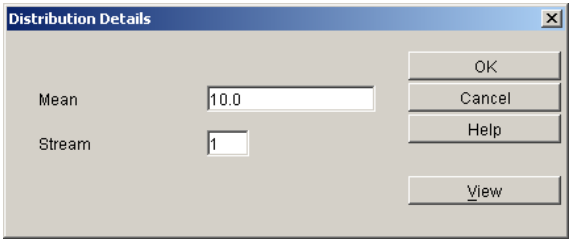
Entity Generation at Intervals of 1 hour

For example, assume Customer Orders to arrive at an exponential rate, with an average of 20 arrivals per hour. Click on the **Interval** pull-down arrow and find the definition for Exponential Distributions. It reads:

Exp(10.0)

Select the distribution. Then, click on the details button to the right of the pull-down arrow.

This displays a dialog for defining the parameters of the distribution:

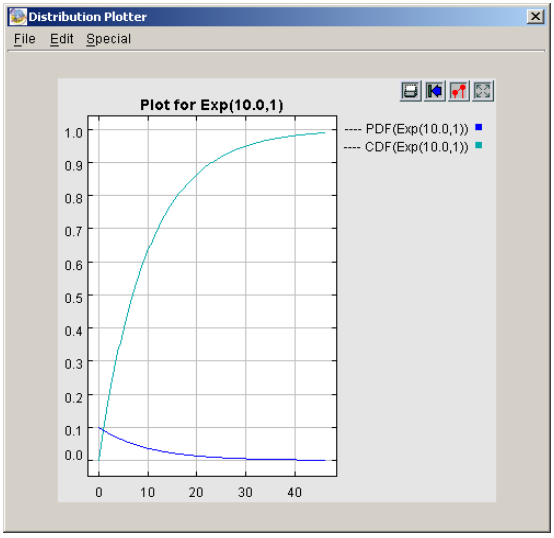


Set the **Mean** value to indicate an average Entity generation rate of 20 per hour.

Assume that Quantity is 1, meaning that only one Entity is produced at each Entity generation event:

- Generate an Entity every 3 minutes to get 20 Entities in an hour (60 minutes).

The **View** button displays a graphical representation of the distribution:

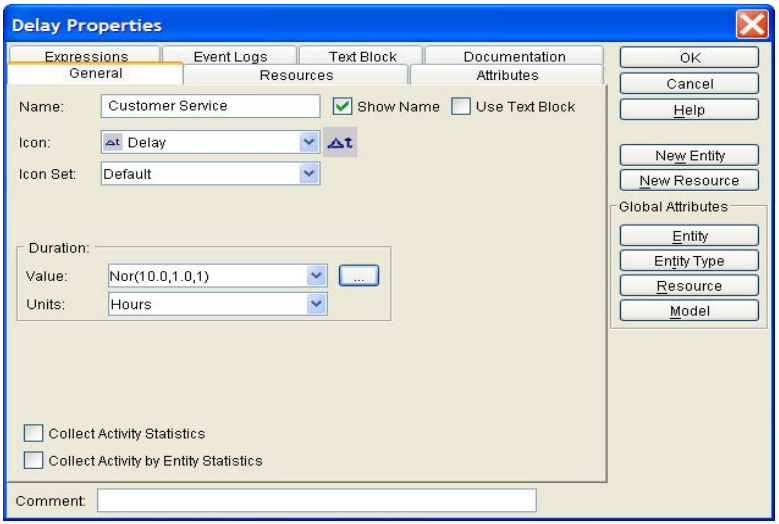


Stream identifies the random number stream used to seed the distribution.

More can be learned about statistical distributions and random number streams in Chapter 3, “Statistical Modeling Constructs,” beginning on page 83.

Delay Activity

Delay Activities, common building blocks found in most models, have two functions: they represent the passage of time during simulation and define the Resources required to perform a task. The cycle time of an Entity traversing the model is the sum of the delays it encounters, i.e., the time spent at the Activities in its path plus any hold time for a condition to be met and the wait time for any Resources.



The **Resources** button opens a dialog for specifying the Resources required to perform an Activity. See Chapter 5, “Resource Modeling Constructs,” beginning on page 126 for instructions on defining Resource requirements for an Activity.

Specifying Delay Duration

Value represents the amount of time required to perform an Activity. This delay time can be expressed as either a constant value or a statistical distribution.

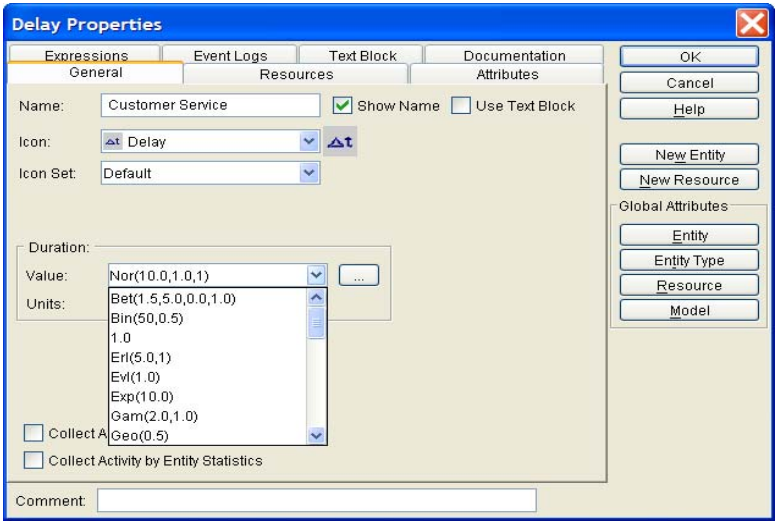
Time **Units** determines if the **Duration** entered is measured as nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

Type the value of the delay duration directly in the field, or select a value from a pull-down list.

A Delay Activity might be defined to represent the task of processing an order. This task takes an average of 30 minutes to perform, though it may take as little as 15 minutes, or as much as 1 hour.

As shown below, a Triangular distribution is often used to represent the time required to complete a task:

1. Click on the arrow to the right of the **Value** field to display a list of distributions:



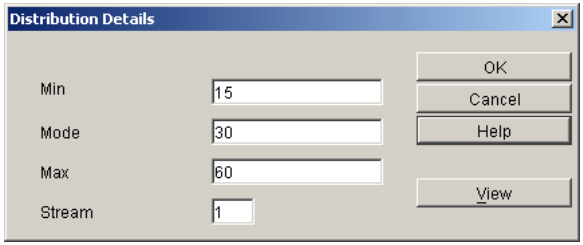
2. Scroll through the list to find the default definition for Triangular distributions. It reads:

   Tri(0.0,5.0,10.0)

   Select the distribution.

3. Click on the box to the right of the **Value** field. Fill in the following values:

   - **Minimum** of 15**, Mode** of 30, and a **Maximum** of 60.
   - Select **Minutes** from the **Units** field.



4. Click on **View** to see what the curve looks like.

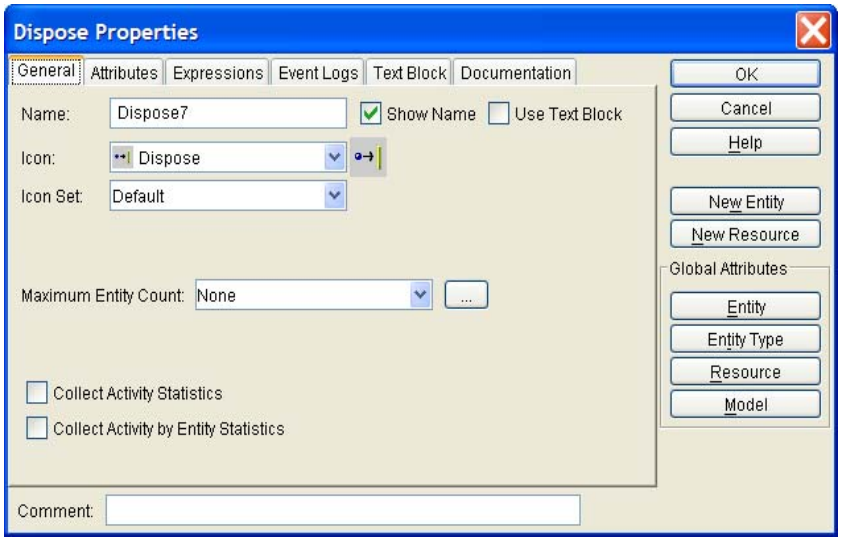
5. Click on **OK** to accept the definition.

See Chapter 3, “Statistical Modeling Constructs,” beginning on page 83 to learn more about these parameters and the topic of statistical distributions.

Dispose Activity

A Dispose Activity disposes of Entities when they are no longer needed in the simulation. The Dispose marks the end of an Entity's cycle time for the purpose of statistic collection (e.g., cycle times and counts).

Dispose Activity Properties



The **Dispose Activity Properties** dialog contains only one unique field: **Maximum Entity Count**. Use this field to set a limit to the number of Entities that can be disposed of at the Dispose during a simulation. The simulation ends if this limit is reached. End a simulation after 1,000 customer orders are processed by setting **Maximum Entity Count** to 1,000.

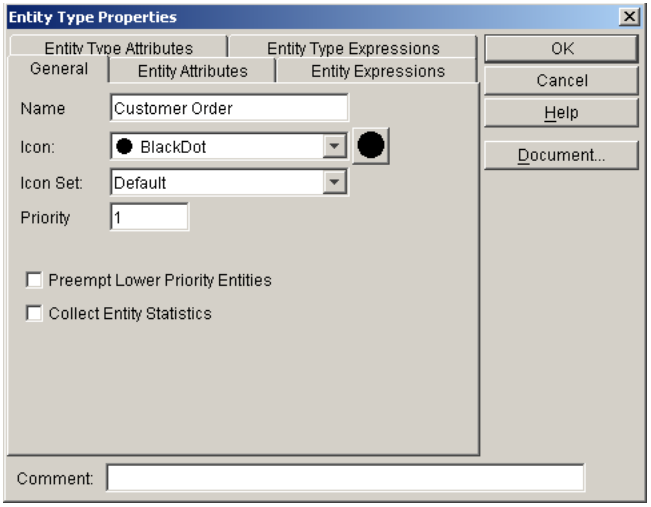
Leaving **Maximum Entity Count** undefined or setting a value of 0 or "none" indicates that there is no limit.

Defining an Entity

A particular *type* of Entity or a particular *instance of* an Entity may be referred to in the model. When an Entity type is referred to, all Entities of a particular type, e.g., customer orders are also referred. An Entity instance refers to an individual Entity (a single customer order).

Defining Entities in SIMPROCESS defines a type; SIMPROCESS generates instances of that Entity during a simulation run. Define Entities in the following manner:

1. Click on **Define** on the SIMPROCESS menu, and then select **Entities...** from the pull-down menu.
2. Click on **Add** to define a new Entity.



3. Specify the **Entity Type Properties**:

   - Entity **Name** identifies the type of Entity. **Name** can be any unique entity name.

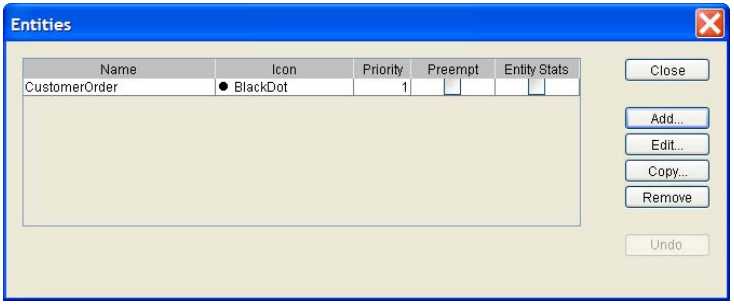
     Double-click on the default name supplied by SIMPROCESS, and enter **Customer Order** as the Entity **Name**.

   - Entity **Icon** is the icon which will represent this Entity during a simulation run. The icon appears during simulation if the **Animation** option is on.

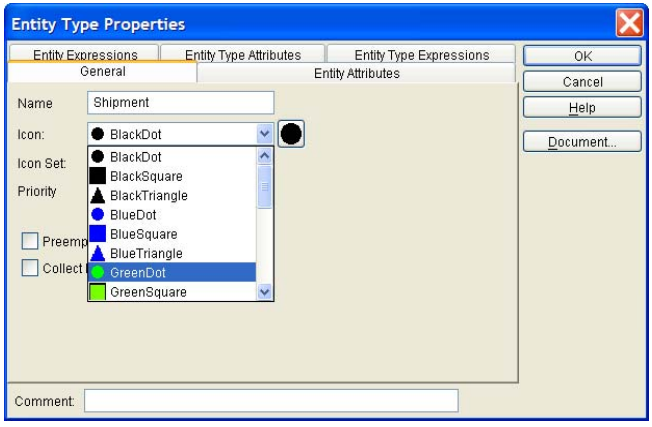
     Click on the downward-pointing arrowhead next to the Entity **Icon** field to get a list of different icons to choose from the currently selected **Icon Set**.

- **Priority** values range from 1 to 100. When Entities contend for the same Resource, the Entity with the highest priority gets precedence.
- **Preempt Lower Priority Entities** sets whether instances of this type will preempt lower priority Entities. If true, when an instance of this type reaches an Activity that uses Resources and there are no Resources available, and the Entity currently using the Resources is a lower priority Entity, this higher priority arriving entity instance will cause the lower priority Entity to release the Resources so this Entity can obtain the Resources and Process.
- **Entity Attributes**, **Entity Type Attributes**, **Entity Expressions**, and **Entity Type Expressions** are used in association with any attributes or expressions defined for this Entity. A choice can be made to create a new copy of an attribute or evaluate an expression every time an instance of an Entity is created. Alternatively, one copy of an attribute can be created or an expression evaluated once for an Entity type and have all instances refer to this value. Attributes and expressions are discussed in Chapter 10, "Customizing a Model with Attributes and Expressions," beginning on page 210.
- **Document** opens an editor window into which extensive comments can be entered about the Entity and the model. This is optional. The Entity document headings can be customized. (See "document Subdirectory" on page 422.)
- **Comment** is used to enter brief text describing the purpose of the Entity.

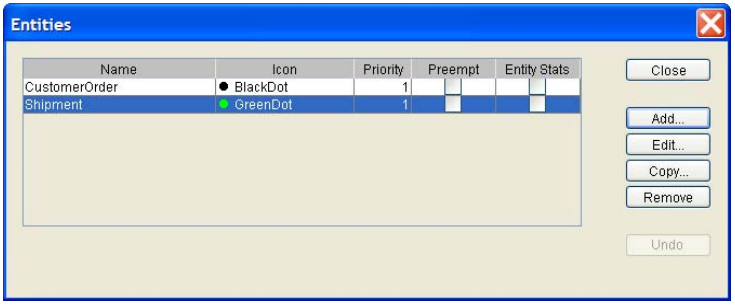
4. Click on **OK** when data entry is completed. The defined Entity is added to the table in the **Entities** dialog.



5. Add another Entity and name it **Shipment**. Click on the pull-down arrow next to the **Icon** field to get a list of Entity icons.



The list may be a lot longer than it first appears. Click near the top of the scroll bar to see more list items. Select *GreenDot*. Then click on **OK**. The icon selected will appear on the button next to the icon list. Clicking the button will bring a dialog that shows the default size of the icon.



Note that the basic properties of Entities added to the model can be edited directly from the table. However, changes made in the table are direct changes to the properties of the Entity and cannot be canceled. Also, the table can be sorted by a particular column by clicking on the column header. Holding the **Shift** key while clicking on a column header causes the table to sort in the reverse order.

Copy the properties of an existing Entity (such as the one just defined) by selecting the Entity in the table and click on the **Copy** button. Enter a different Entity **Name** and make any other changes on the **Entity Type Properties** screen, and then click on **OK**.

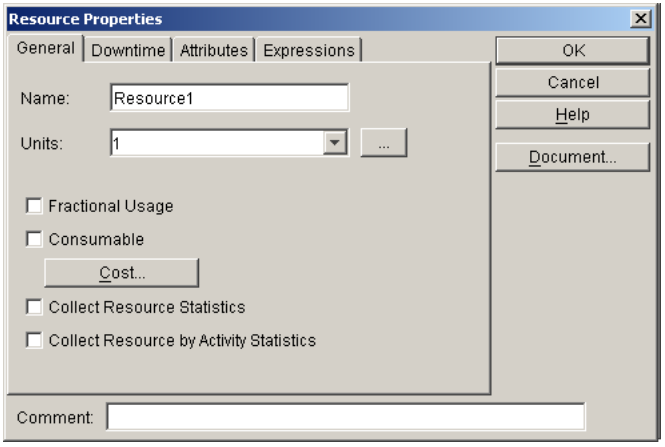
Remove an existing Entity by selecting the Entity and clicking on the **Remove** button. The **Undo** button restores Entity definitions that have been removed. Click on **Close** when Entities are defined.

Defining Resources and Processes

Resources

The next thing to define in the model are the Resources required to process Customer Order Entities. To keep things simple, define just one Resource, the clerks needed to process customer orders.

1. Select **Resources...** from the **Define** pull-down menu.
2. Select **Add** to define a new Resource.



See Chapter 5, “Resource Modeling Constructs,” beginning on page 126 for an explanation of the remaining options and commands, and for more details on defining Resources, including pre-defined Resource types.

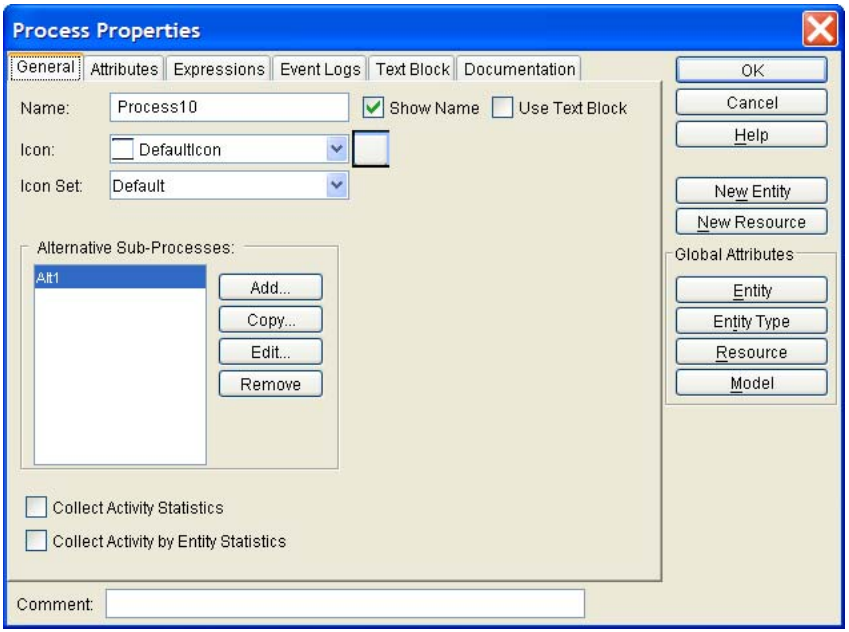
Processes

A SIMPROCESS Process defines Processes hierarchically. In this example, we will define a Process that indicates how customer orders are handled

Select the **Process** button from the Palette bar and click on the layout.

Display a dialog for defining the Process. Do this by either:

- Clicking on the **Process** icon to select it, and then pressing **Alt+Enter**
- Selecting the **Process** icon, and then selecting **Edit** from the menu bar, followed by **Properties...**



Alternative Sub-Processes

A Process may consist of a set of Alternative sub-processes. Each sub-process can represent an alternative implementation of the Process. This allows the creation of many variations of a Process and keeps them organized in one place.

Only one sub-process can be active at any point in time. An experiment may be run with Alternative sub-process 1 active to measure the overall performance of the model. Alternative sub-process 2 can then be run and results compared.

SIMPROCESS defines a single default sub-process when a Process is created. Renaming the sub-process to something more meaningful for the model is accomplished by:

1. Selecting it from the **Alternative Sub-Processes** list on the **Process** dialog.
2. Clicking **Edit** to modify the sub-process definition.
3. Highlighting the existing name and typing over it. For this example, call the sub-process **Main**.
4. Click on **OK**.

The new name appears in the **Alternative Sub-Processes** list and becomes the sub-process.

More sub-processes may be added to the Process by clicking on **Add** and naming the new sub-process. Activate a different sub-process by selecting it from the **Alternative Sub-processes** list.

Sub-processes may be deleted with the **Remove** command button and copied using the **Copy** button.

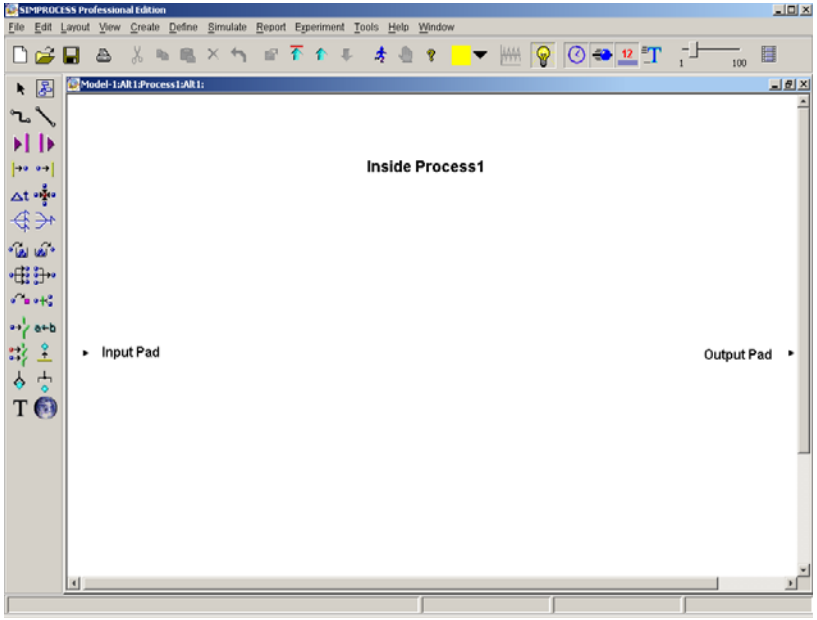
Click on **OK** when the **Process** is defined.

Adding Detail to a Process

Once a Process is defined, define the Activities and Processes that make up the Process.

Right-click on the **Process** icon and choose **Descend** to open the layout of the currently active sub-process

A blank layout is shown, except for two Pads: an input Pad on the left and an output Pad on the right. If the output Pad is not visible, scroll to the right.



These Pads connect any Processes and Activities at this level of the sub-process to the Activities and Processes at the next higher level. Once the input and output Pad are connected by Connectors,

Entities flow from level to level.

Activities (and Processes) may be added within the sub-process to detail the tasks being performed.

NOTE: Make sure the Input and Output Pads are connected on all sub-processes. If this is not done, Entities will have no path to follow across the Process. Entities entering the Process will never emerge again.

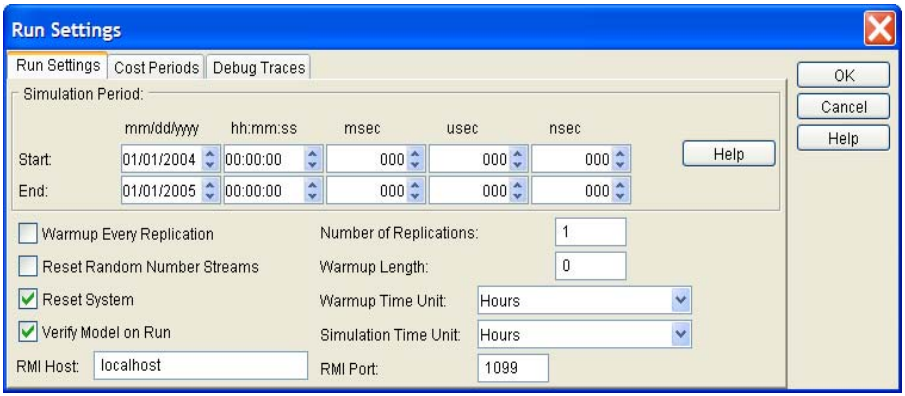
Simulation Setup

Two steps are needed before running a simulation:

- Set the run time parameters for the simulation. This could include start and end dates or number of times to repeat the simulation.
- Set animation parameters.

Run Settings

Select **Simulate** from the SIMPROCESS menu and then click on **Run Settings...** to set run time options.



Setting the Start and End Dates

The values chosen for the **Start** and **End** fields determine how long the simulation runs, in calendar time. A simulated month of processing can be specified as:

Start: 1/1/2004 00:00:00:000:000:000

End: 2/1/2004 00:00:00:000:000:000

This indicates a starting date of January 1, 2004, at midnight, and an end date of February 1, 2004, at midnight. The simulation terminates as soon as the clock strikes midnight at the end of January 31.

A time must be entered or the hours, minutes, seconds, nanoseconds, microseconds, and

milliseconds fields default to zero.

NOTE

Remember that **Start** and **End** dates for objects in the model, must be coordinated those with the simulation run dates.

For example, a Generate Activity with **Start** and **End** dates that fall outside of the simulation **Start** and **End** dates will not generate Entities during the simulation. Or, a **Resource Downtime** with **Start** and **End** dates outside of the simulation **Start** and **End** dates will not be applied.

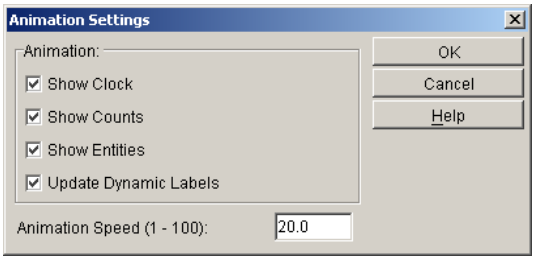
Run Dates and the Real Calendar

Both entity generation schedules and resource downtime schedules can be based on a day of the week. SIMPROCESS calculates the day of the week, as well as the month, year, and time of day, at any moment in a simulation. It maps the simulation dates to the real calendar. For example, in 2004 the year begins on a Thursday.

Setting the Simulation Time Unit

SIMPROCESS allows the **Simulation Time Unit** to be set, which is the time unit of the simulation clock. The simulation clock must maintain a constant time unit. The default is *Hours*. Even though each individual time unit can be different, those times are converted to the time unit of the simulation clock. The default time units for simulation time on real-time plots is set. Also, this is important for reducing rounding errors. If the primary delays in the model are in seconds or less, the time unit of the simulation clock should be set to *Seconds* or less. Converting a delay in nanoseconds (or even seconds) to hours could result in rounding errors, whereas converting a delay in nanoseconds to seconds or less would not.

Animation Settings



Show Clock turns the simulation time clock on or off while the simulation is running.

Show Counts. If **Show Counts** is turned on, each Activity or Process will display a number above its icon.

- Generate Activities show the number of Entities generated.
- Dispose Activities show how many Entities have been disposed.
- All other Activities and Processes show how many entities are in that Process or Activity.

Show Entities turns the display of Entities on or off during the animation. Showing Entities assists with visualizing the workflow.

Update Dynamic Labels turns the display of dynamic labels on or off during the animation.

Animation Speed. Changes the **Animation Speed** during the simulation. The fastest value is 100, and the default is 20. A smaller value is better while debugging the model.

Running a Simulation

Start the simulation running, either by clicking the blue runner icon on the tool bar, or selecting **Simulate** from the SIMPROCESS menu bar, followed by **Run**.

Before starting the simulation, SIMPROCESS does two things:

1. Prompts for saving the latest changes to the model
2. Checks the model for errors.

SIMPROCESS issues informational messages and aborts the simulation if errors are found.

Choose **Verify Model** from the **Simulate** menu before running to check the model for errors before running a simulation.

Running a Simulation with Model Parameters

If the model has User-defined Attributes which were selected as Model Parameters, when the simulation run is started, SIMPROCESS will prompt for initial values for those Model Parameters.

The Model Parameters are displayed in a table. The column under **Parameter** gives the name of the User-defined Attribute. The **Value** column shows the value the attribute will have at the start of the simulation run.

To change the value of a Model Parameter, select it in the table. The Description of the selected parameter will be displayed below the table along with its default value and the mode of its value (integer, real, etc.)

The next step is to enter the desired value of the Model Parameter in the **Value** field. If **Reset** is pressed, the selected Model Parameter will return to its default value. The **Reset All** button, under the **Help** button, will set the value of all the Model Parameters back to their defaults.

Creating Model Parameters from User-defined Attributes is covered in Chapter 10, “Customizing a Model with Attributes and Expressions,” beginning on page 210.

Model Parameters can be changed during a simulation run by selecting **Change Model Parameters** from the **Simulate** menu.

Allowable Actions During a Simulation

While a simulation is running, a Process can be descended into to view Entity movement within the Process hierarchy. Descending into a Process is done by using **Descend** on the **View** menu, clicking

the down arrow on the tool bar, right clicking on a Process and choosing **Descend**, or by double-clicking on a Process.

Choose **Ascend** on the **View** menu to ascend to a higher level of the model hierarchy. Click the up arrow on the tool bar, right click on blank area and choose **Ascend**, or double-click on any blank area of the model layout. Choose **Go To Top** instead of **Ascend** to ascend to the top level of a model.

The **Simulate** option on the menu bar causes the following options to occur:

- Pause the simulation
- Resume simulation after a pause
- Stop the simulation before its scheduled end
- Click on **Animation Settings** to change animation options. The simulation pauses while this is being done. Changing the animation options using the tool bar does not pause the simulation.

Double click on an **Activity** icon to bring up its properties dialog. However, any changes made will not be reflected in the running simulation.

Animation can be recorded for playback after the simulation ends. (See “Post Simulation Animation” on page 149.)

Standard Report

After the simulation run has completed, the Standard Report may be displayed to view output statistics for the model. From the **Report** menu bar, choose **Display Standard Report**.

This will open the **Display Standard Report** dialog. In the **Report Replications** list box (if the model ran for multiple replications), select an individual Replication, the Average of All Replications run, or the Sum of All Replications run. Typically, the report of interest will be the Average of All Replications report. **Calculate Confidence Intervals** is activated if the Average of All Replications report is selected, which allows selection of 90%, 95%, or 99% confidence intervals for each performance measure. Select to view the Standard Report with a **Text Editor** (Wordpad by default) or with a **Spread Sheet** and press the **Display Report** button to open the report.

See Chapter 8, “Output Reports,” beginning on page 162 for more detail on the Standard Report.

CHAPTER 3

Statistical Modeling Constructs

SIMPROCESS allows the analyzing of processes using discrete event simulation. This means that SIMPROCESS models systems by taking the processes that happen in the real world and breaking them down into the key events that occur. Parts move to a station in a factory, are processed, and then move to the next station. If one part goes into a station and one part comes out, then the most important aspect of modeling the station would be to capture the processing time (which, in the real world, will vary due to any number of factors) by a statistical distribution.

A statistical distribution is used to give the model the randomness that always occurs in the real world. Of course, if things in the real world never varied, simulation would not be needed! Mean-value analysis of your system would suffice. Mean-value analysis is a simple way of predicting system performance by looking only at average rates. Unfortunately, the real world almost never matches the performance predicted by mean-value analysis, because statistical fluctuations almost always need to be taken into account.

Expertise in statistics or modeling is not needed to use SIMPROCESS, though; just having some idea of how things vary is enough. If data shows it usually only takes 5 minutes for a clerk to process some paperwork, but it can take as long as 15, that is the beginning of a statistical model of that clerk. Exact answers are not necessary, just general behavior. Introducing a small amount of randomness through simulation can be all that is needed to transform a simplistic mean-value analysis into a realistic model.

SIMPROCESS provides a visual flow through the system, in addition to being able to model

processes' statistical nature. It is very difficult to know how people, machinery, deliveries, and resources are going to interact in a proposed system. SIMPROCESS shows how these interactions might occur while still in the planning stage. Animation provides valuable insight into how things work and how they could work.

Random Number Generation and Standard Distributions

Random Number Generation

SIMPROCESS contains 215 random number streams, each having a different random number seed. You can view the seeds available from **Seeds** on the **Define** menu bar.

The purpose of using different random number streams in the model is to control variance. This is an advanced topic well beyond the scope of this manual. Please refer to texts on statistics and randomness, including *Simulation Modeling and Analysis* by Law and Kelton (McGraw-Hill).

Standard Distributions

SIMPROCESS includes many standard probability distributions built in. You can also create empirical distributions from your own data. The following pages provide brief descriptions of each standard distribution.

Choosing the Right Distribution for Your Data

It is not always clear which of the standard distributions should be used. Fortunately, simulation results are usually not highly dependent on the choice of distributions. A distribution with approximately the right shape should be adequate.

Here are some guidelines which can help you choose the right distribution.

ExpertFit uses sophisticated statistical tests to determine the best fit distribution to a set of experimental data. Additional information on ExpertFit is covered in the ExpertFit documentation.

Poisson: Used to model arrivals where the quantity within a time frame is known. Parameter: Mean.

Exponential: Used to model the time between arrivals. Parameter: Mean.

Normal: Bell-shaped curve; avoid when mean is near zero. Also, the normal distribution is not usually a good distribution for service times since service times are usually skewed to the right. Parameters: Mean, Standard Deviation

Lognormal: Can be good distribution for data that is skewed. Parameters: Mean, Standard Deviation

Triangular: Useful distribution for data that has the least amount of time, the most likely time, and the most amount of time it takes to perform a task. Parameters: Minimum, Mode, Maximum

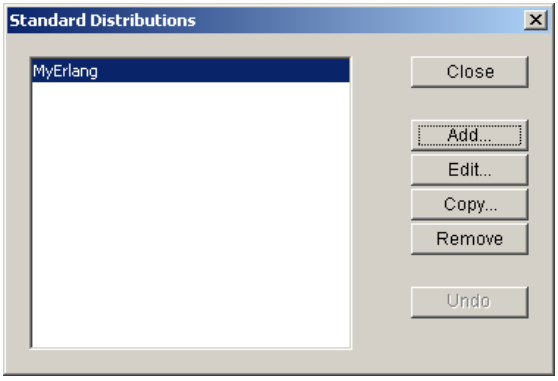
A complete listing of the statistical distributions available in SIMPROCESS is available in Appendix D. See “Statistical Distributions” on page 425.

User Defined Distributions

There are two methods for creating ***User Defined Distributions*** listed on the **Define** pull-down menu. The first, **Standard...**, customizes an existing SIMPROCESS distribution. The second, **Tabular...**, creates a statistical distribution from discrete data points using a table format. These User Defined Distributions can be used anywhere in the model where a statistical distribution is specified.

User Defined Distributions Procedures

1. Using the **Define Distributions** pull-down menu, select **Standard....** Use this dialog to **Add, Edit, Copy,** or **Remove** User Defined Distributions found in the list box. **Undo** retrieves a distribution that has been removed.

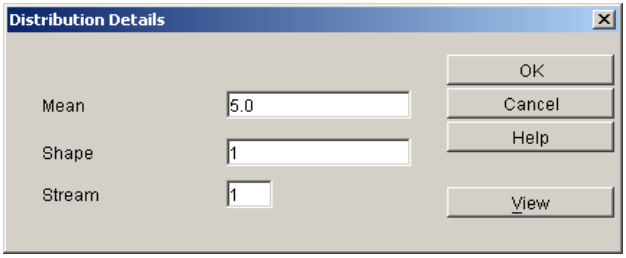


2. Choosing the **Add** or **Edit** button brings up another dialog as shown below, where you type in the **Name** and distribution:

   Name is any unique non-blank user distribution name.

   Select a distribution for modification.

3. Using the distribution text box, either change the parameters of the distribution within the parentheses or select the details button (three dots). This button opens a dialog containing the parameter descriptions, e.g., Erlang parameters.

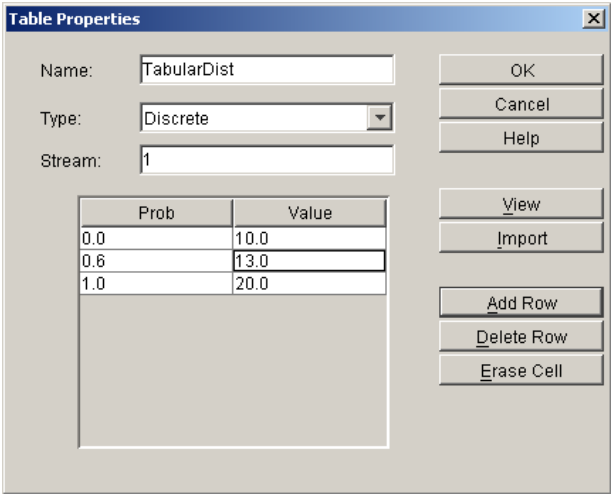


4. To see the PDF (Probability Distribution Function) and CDF (Cumulative Distribution Function) plotted, choose the **View** button from the dialog shown in Step 3. The PDF is labeled on the left y-axis, the CDF on the right y-axis.
5. The graph can be saved to a file. To continue, select **Close** from the graph's **File** pull-down menu.
6. Once the data is entered, choose **OK**, and the defined User Distribution is added to the list box. This User Defined Distribution can now be used anywhere in the model where a statistical distribution is specified.
7. To copy an existing User Distribution, select the distribution, choose the **Copy** button, and you can enter another **Name** for the distribution.
8. To remove an existing User Distribution, select the distribution, and choose the **Remove** button.
9. Choose the **Close** button to finish with User Distributions.

Tabular Distributions

Tabular Distributions creates a statistical distribution from a table of discrete data points.

1. Select **Tabular...** from the **Define Distributions** pull-down menu. Use this dialog box to **Add, Edit, Copy,** or **Remove** Tabular Distributions in the list box.
2. Choosing the **Add** or **Edit** button brings up another dialog as shown below:



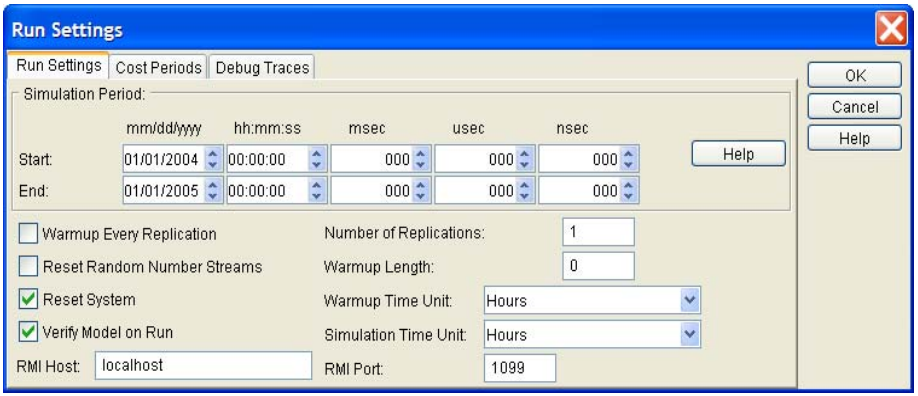
3. Type in the **Name** as any unique non-blank User Distribution name.
4. **Type** is selected from the list box. Choose either a **Discrete** or **Continuous** probability distribution function. If **Discrete** is chosen, only the exact values indicated in the right column will be chosen when the distribution is sampled. If **Continuous** is chosen, SIMPROCESS will interpolate from the specified **Values** and the probabilities associated with them.
5. To update the table, point and click on the cell you wish to modify. Type the number in the table cell directly.

   Rows may be added and deleted by clicking on a cell and then choosing the appropriate button on the right. The row will be added above the one selected. The **Erase Cell** button causes the entry in the selected cell to be erased.

   A table may also be populated by importing data from a text file using the **Import** button.

   Choose the **View** button to see the PDF and CDF plotted. The graph can be saved to a file. Select **Close** from the graph's **File** pull-down menu to continue.
6. Once the data is entered, choose **OK**, and the Tabular Distribution is added to the list box. This Tabular Distribution can now be used anywhere in the model where a statistical distribution is specified.
7. To copy an existing Tabular Distribution, select the distribution, choose the **Copy** button, and enter another **Name** for the distribution.
8. To remove an existing Tabular Distribution, select the distribution, and choose the **Remove** button.
9. Choose the **Close** button when the Tabular Distributions are complete.

Run Settings



Run Settings

Simulation Period

The **Simulation Period** determines how long the simulation will run. It is given in calendar and time format. Choose an appropriate time span to see all aspects of the system.

Warmup Every Replication

When selected and the values for both the **Number of Replications** and **Warmup Length** are greater than 0, SIMPROCESS will start collecting statistics after the **Warmup Length** has expired for each replication.

Warmup Length

If a **Warmup Length** is entered SIMPROCESS will start the collection of statistics for the model run, after the end of the **Warmup Length**. This gathers information on your system after it has reached "Steady State."

Warmup Time Unit

The **Warmup Time Unit** specifies the time unit for the **Warmup Length**. It defaults to Hours.

Simulation Time Unit

The **Simulation Time Unit** specifies the time unit for the simulation clock. It defaults to Hours.

Reset System

Resets the system to the initial conditions before each replication.

Verify Model on Run

Turns the automatic model verification on or off at the beginning of a simulation. The verification process checks to make sure all pads are connected.

Number of Replications

When the model contains randomness (represented by statistical distributions) the model should be run for multiple replications. This averages the results and gives a more accurate picture of "most likely" outcome of the scenario being modeled.

Reports are gathered for each replication and the Total and Average of all runs.

Reset Random Number Streams

This option resets the **Random Number Stream** before starting each new replication. Typically, this should not be selected. In general terms, the reason for running the model for multiple replications is to test how randomness affects the system. Turning this option on negates that test.

RMI Host

This indicates the host on which SPServer will be located if the model has an External schedule defined. Defaults to "localhost." (See "Adding an External Schedule" on page 286.)

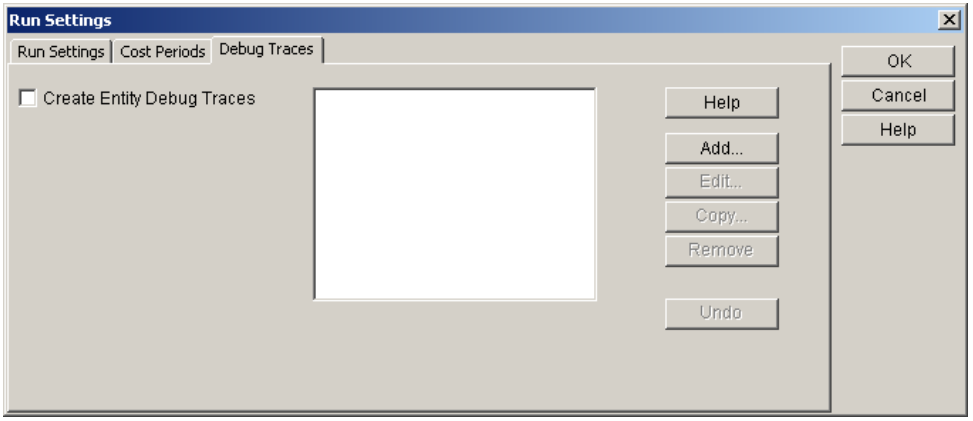
RMI Port

This indicates the TCP port to use on the **RMI Host**. Defaults to 1099. (See "Adding an External Schedule" on page 286.

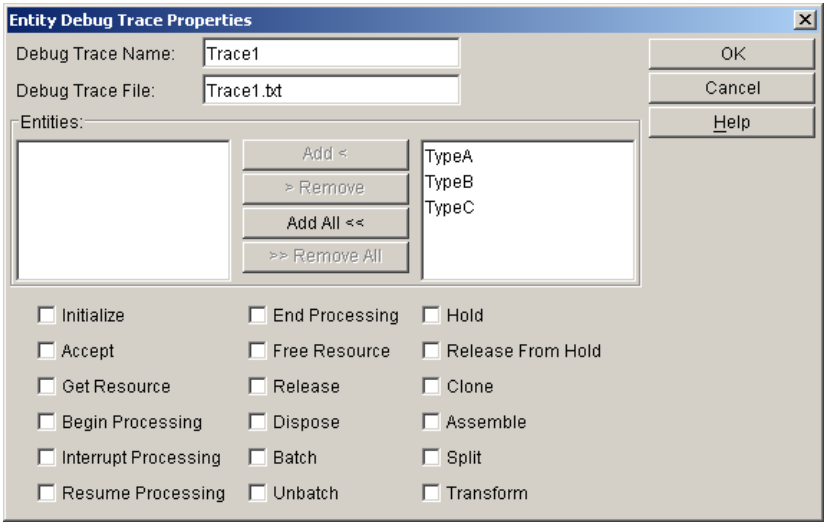
Cost Periods

This tab sets the frequency over which the ABC Reports will be collected. The name of the currency that the ABC Reports will use can also be set. (See "Setting Up Cost Periods" on page 156.)

Debug Traces



This tab turns on/off debug tracing and defines debug traces. If checked, **Create Entity Debug Traces** causes the creation of the debug traces defined in the box to the right. If no debug traces are defined, no debug traces are created during the simulation run. Click the **Add...** button to define a debug trace. This brings up a dialog for defining the debug trace.



Debug Trace Name is the name of the trace that will appear in the list of traces. **Debug Trace File** is the name of the debug trace file to be created. If no path is included, the file will be created in the directory of the model. Select the **Entities** to be included in the trace. Entity types to be included should be moved

from the list of entities on the left to the list of entities on the right. The checkboxes at the bottom are the entity actions that can be included in the trace. Note that the **Clone**, **Assemble**, **Split**, and **Transform** actions apply to the entity that initiates the action, not the entity or entities that result from the action.

Each debug trace file is a tab delimited file. The replication is added to the file (Replication 1, Replication 2, etc.) and then a header line consisting of Action, Activity, Entity, SequenceNum, and SimTime. Each action added to the file consists of the action name (Initialize, Accept, etc.), the name of the activity, the name of the entity, the sequence number of the entity, and the simulation time.

CHAPTER 4

Activity Modeling Constructs

The SIMPROCESS Activities that were not covered in Chapter 2, "SIMPROCESS Basics," beginning on page 53, can be divided into two categories: Entity Related and Resource Related.

Entity Related

These Activities coordinate groups of Entities and includes:

- *Assemble*. Receives two or more Entities and assembles them into a single Entity and releases the Entity.
- *Branch*. Routes Entities through different Connectors of the model network.
- *Merge*. Routes Entities from different Connectors onto one Connector.
- *Batch*. Stores Entities until conditions set by the user are met, and then releases the Entities in one batch. The Entities emerge as a single unit, but retain their individual idEntity.
- *Unbatch*. Separates a batched Entity into its constituent parts (Entities).
- *Split*. Divides an Entity into parent and child Entities that can undergo parallel processing.
- *Join*. Reunites families of Entities that were created in Split Activities
- *Transform*. Transforms an arriving Entity into a different Entity type, and releases one or more Entities of the new type.

- *Transfer.* Routes an entity from one model layout to another model layout without using a connector, or transfers an entity to another model.
- *Clone*. Makes duplicate copies of Entities.
- *Gate*. Accumulates Entities until a condition is met and then releases a specified number of them.
- *Assign*. Assigns values to global Entity and model attributes and sets Entity priorities.
- *Synchronize*. Coordinates the release of various Entities.

Resource Related

Unlike other SIMPROCESS Activities, these Activities affect Resources, not Entities:

- *Replenish Resource*. Adds capacity to consumable Resources.
- *Get Resource*. Obtains a Resource and holds on to it across several Processes and Activities.
- *Free Resource*. Releases Resources obtained by Get Resource Activities.

Resource-related Activities are described in Chapter 5, “Resource Modeling Constructs,” beginning on page 126. The Entity-Related Activities are covered in this chapter.

Entity-Related Activities

Activities that are used to coordinate grouping of Entities are addressed here. The type of coordination to be done is specified at the Activity. Entities are queued up in these Activities (except for unbatch, split) until the conditions are met. This queueing time is reported as "Hold for Condition" in the reports. This is reported separately from the "Wait for Resource" queueing time which can accumulate at any Activity for which a Resource requirement has been specified.

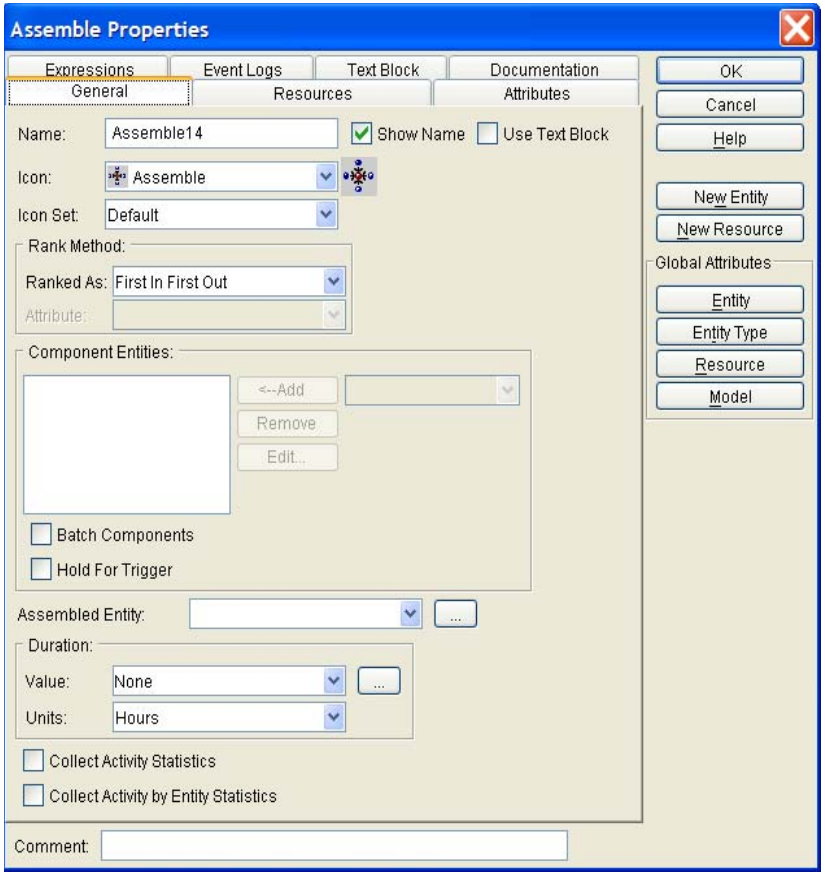
- Assemble Activity
- Batch Activity
- Unbatch Activity
- Gate Activity
- Synchronize Activity
- Split Activity
- Join Activity

Assemble Activity

The Assemble Activity is used to build several Entities into a single output Entity. Consider a case where two approvals and a check are required to form one "approved loan." An Assemble Activity can be used to model this process.

Assemble has two input Pads (*Component* and *Trigger*) and two output Pads (*Out* and *NoMatch)* that determine Entity behavior. The Component Pad places incoming Entities into a queue until all Entities to be assembled have arrived. An Entity entering the Component Pad not on the component Entity list will immediately leave the Assemble Activity through the No Match Pad.

The Trigger Pad is only relevant if **Hold for Trigger** is selected as one of the Activity's options. Entities entering the Trigger Pad can trigger the release of the assembled Entities. Assembled Entities are only released when an Entity, such as a Customer Order, arrives. The trigger can be released by using the FireTrigger System Method instead of having an Entity enter the trigger Pad. The name of the Activity must be unique within the model for the system method to work properly. See "SIMPROCESS System Methods" on page 465.



Dialog Field Definitions

Rank Method sets the rank method of the queue for the Entities to be assembled. There is a separate queue for each component Entity type. The rank method is the same for all queues. The default is **First In First Out.** The rank methods are:

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**

- **Lowest Attribute Value First**

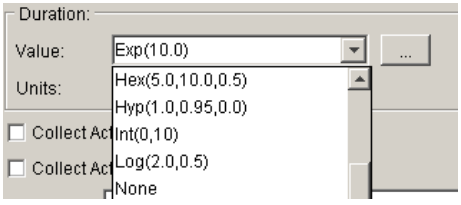
Selecting **Highest Attribute Value First** or **Lowest Attribute Value First** will cause the **Attribute** field to be active. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

Component Entities is a list of component Entities to be converted to assembled Entities. Entities on the list are queued until the specified quantity of each Entity type has entered the Assemble Activity.

- **Add:** Opens a dialog to define component Entities
- **Edit:** Opens a dialog to modify the component Entity definition
- **Remove:** Removes the selected component Entity
- **Batch Components:** Releases the assembled Entity as soon as all component Entities are available for assembly
- **Hold for Trigger:** Holds output Entities until an Entity enters the Trigger Pad.

Assembled Entity shows the Entity type to be released after all component Entities have entered the Activity. A combo box provides a list of defined Entity types.

Duration shows where the delay time of the Activity is specified. The time specified in the **Duration** will be applied after the Activity and will be reflected in the Cycle Time of the Assembled Entity.

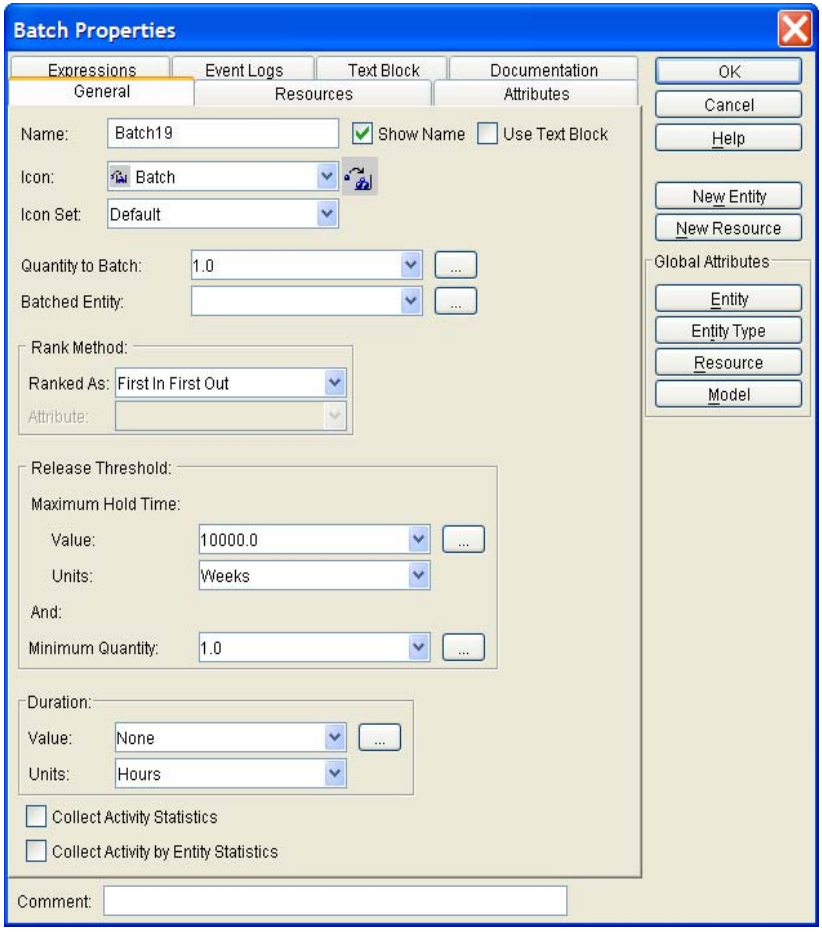


- **Value:** The amount of time required to perform this Activity. Use the combo box to select a statistical distribution or enter a constant value directly in this field.
- **Units:** Determines if the **Duration** entered is measured as nanoseconds, microseconds, milliseconds, seconds, minutes, hours, days, weeks, months, or years.

Batch Activity

The Batch Activity combines several Entities into one Entity while retaining the identity of the original Entities. The resultant Entity travels throughout the process as a single Entity. It can be disassembled into its constituent Entities using an Unbatch Activity at some later time.

The Batch Activity is useful when combining several Entities (e.g., merchandise ordered by various customers) into a parent Entity for transportation. After the transportation Activities, the parent Entity can be broken down into the Entities that comprised it. Statistics can be collected for the batched Entity separately from its constituent members.



Dialog Field Definitions

Batched Entity is the type of Entity that will serve as the container or *parent* Entity. An Entity of this type is created and all other Entities become children of the parent.

Quantity to Batch is the maximum number of Entities that fit in one batch.

Maximum Hold Time: is the maximum amount of time to hold before a batch that has met the **Minimum Quantity** requirement is released.

Minimum Quantity is the minimum number of Entities that must be in a batch before it can be released.

Duration is the time specified for a Batch Activity that will be applied after the Activity. It will be reflected in the Cycle Time of the Batched Entity.

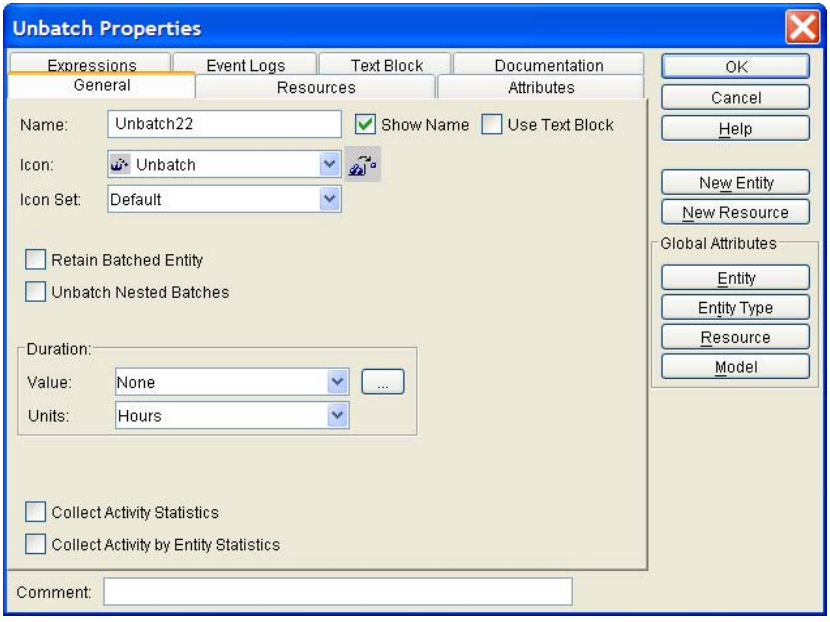
Rank Method sets the rank method of the queue for the Entities to be batched. The default is **First In First Out**. The rank methods are:

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First.**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

Unbatch Activity

An Unbatch Activity separates a batch Entity into its constituents (children) and then destroys (*Disposes*) the parent Entity. Many levels of batching are possible, i.e., batches can be composed of batches. The Unbatch Activity defaults to only disaggregate one level of batch at a time. **Unbatch Nested Batches** must be selected to disaggregate all levels.



The time specified in the **Duration** will be applied before the Activity when the Delay time is set for an Unbatch Activity. It will be reflected in the Cycle Time of the Batched Entity.

The Unbatch Activity defaults to disposing the Batched Entity that enters the Activity. **Retain Batched Entity** must be selected for the Batched Entity to not be disposed,. The Batched Entity will continue through the simulation with no child Entities.

Gate Activity

The Gate Activity accumulates Entities until some number of Entities have been received or until a signal is received from another Activity to release Entities. It then sends a designated number of Entities out into the model. Entities can be, but do not have to be, batched in a Gate Activity.

A Gate Activity has two Pads that determine Entity behavior, the *Hold* Pad and the *Trigger* Pad. The Hold Pad, located on the lower left of the Gate icon, is a queue for incoming Entities. Entities that arrive at that Pad are stored here. The Trigger Pad, located on the upper left of the Gate icon, disposes of incoming Entities and causes any Entities stored on the Hold Pad to be released.

A Gate Activity has two gating policies that can be effective concurrently. The first gating policy is

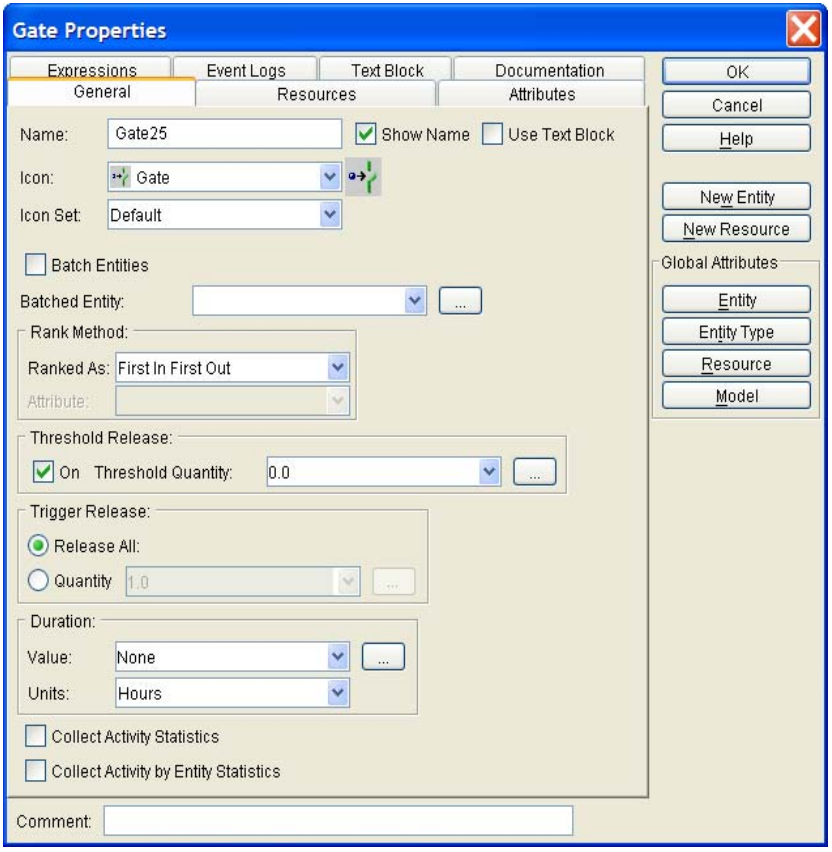
called **Trigger Release**. An Entity is disposed of when it arrives at a Trigger Pad, and it triggers the release of the number of Entities as specified in the **Trigger Release Quantity** field. A Trigger Pad can synchronize the flow of Entities between different Activities.

The Gate Activity can be used as a buffer or queue to hold material from one section of the model until a condition is met in another part of the model. A Trigger Entity is sent to the Trigger Pad of the Gate Activity when that condition is met.

An example of this would be if customer orders are printed out and sent on to the shipping department on an hourly basis. This could be reflected in the model by a Gate Activity, which is triggered when it receives an Entity that is generated hourly by a Generate Activity.

The second gating policy is called **Threshold Release**. It allows the release of some number of Entities once a threshold number of Entities have arrived. This policy is useful, for example, in cases where a truck must wait until it is full before it departs.

Gating policies can be effective concurrently, so this Activity can implement a truck leaving when it is full or on the hour, even if it is not full.



Dialog Field Definitions

Batch Entities will batch the Entities before leaving the Activity.

Batched Entity is the type of Entity that will serve as the container or *parent* Entity. An Entity of this type is created, and all other Entities become children of the parent.

Rank Method sets the rank method of the queue for the Entities waiting at the Gate. The default is **First In First Out**. The rank methods are

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**

- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run-time error will occur if an Entity enters that does not have the selected attribute defined.

Threshold Release

- **On/Off:** Enables/disables the **Threshold Release** feature. **Threshold Release** is on when the check box is selected.
- **Threshold Quantity:** The threshold number of Entities to accumulate and release when the **Threshold Release** is checked on.

Trigger Release

- **Release All:** Releases all the accumulated Entities when a Trigger Entity has been received on the Trigger Pad.
- **Quantity:** The number of Entities to release when a Trigger Entity has been received on the Trigger Pad. This is used with the Trigger Release policy. The value can be a constant integer or can be derived from a statistical distribution.

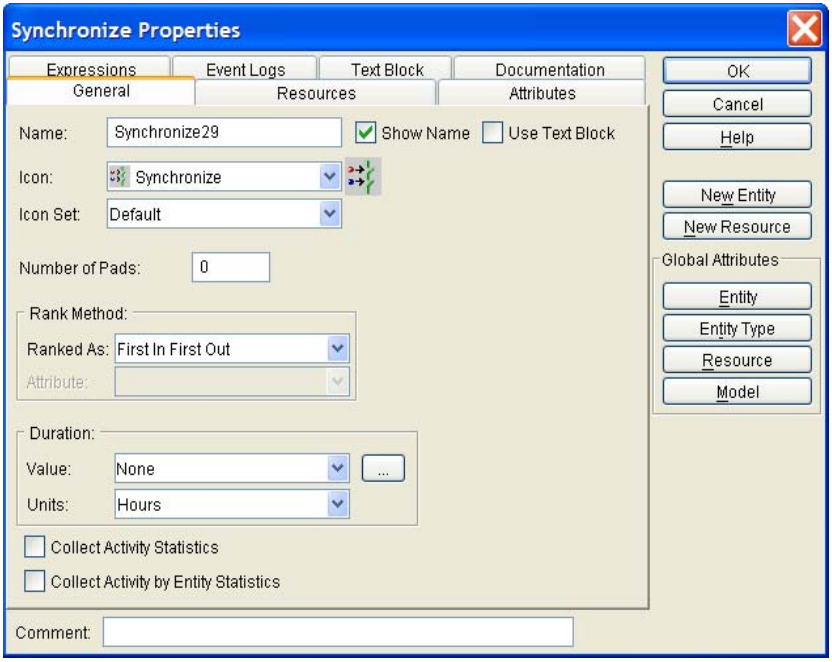
The Trigger can be released by using the FireTrigger System Method instead of having an Entity enter the trigger Pad. The name of the Activity must be unique within the model for the system method to work properly. See “SIMPROCESS System Methods” on page 465.

Duration is the time specified for a Gate Activity that will be applied when the Entities are released. Each Entity released will have a duration, unless the Entities were batched, and then only the Batched Entity will have a duration.

Synchronize Activity

A Synchronize Activity coordinates the release of many Entities, which may be of various types. The number of input/output Pads for a Synchronize Activity is specified. Entities arriving at each Pad are stored in separate queues. Each queue releases one Entity to its corresponding output Pad when each queue has at least one Entity.

A project may require four jobs to be done in parallel, with the work kept in step at various tasks within the process. All others must be at the same stage of completion before work can proceed on one job. Synchronize Activity may be used with four Pads to model the wait time and release of the parallel tasks.



Dialog Field Definitions

Number of Pads is the number of pairs of input and output Pads required by this Activity.

Rank Method sets the rank method of the queues for each input Pad. Each queue will have the same rank method. The default is **First In First Out**. The rank methods are:

- **First In First Out**
- **First In Last Out**
- **Earliest Created First**
- **Latest Created First**
- **Highest Priority Value First**
- **Lowest Priority Value First**
- **Highest Attribute Value First**
- **Lowest Attribute Value First**

The **Attribute** field will be active if **Highest Attribute Value First** or **Lowest Attribute Value First** is selected. Select the desired attribute from the list. If the selected attribute is a local Entity instance or Entity type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

Duration is the time specified for a Synchronize Activity that will be applied to each Entity when the Entities are released.

Entity Control Activities

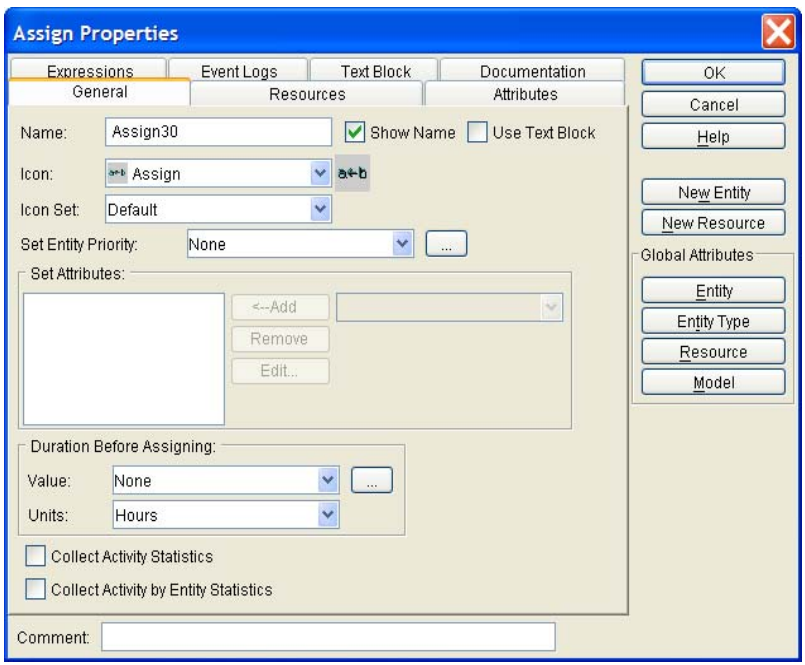
This section discusses Activities that are used in the control of Entities through the process model:

- Assign Activity
- Transform Activity
- Branch Activity
- Merge Activity
- Transfer Activity
- Clone Activity

Assign Activity

The Assign Activity is one method used to assign values to attributes. The Assign Activity can also be used to change the priority of an Entity.

The Assign Activity is covered in detail in “Assign Activity,” beginning on page 222.



Dialog Field Definitions and Buttons

Set Entity Priority sets or changes the Priority of an Entity. The priority defaults to **None**, which means the Entity priority is not changed. Entity priority must be within the range 1 to 100. If a value less than 1 is returned from the distribution, then the Entity priority is not changed. If a value greater than 100 is returned from the distribution, then a warning is displayed, and the Entity priority is set to 100.

NOTE: Entities with a higher priority use available Resources first.

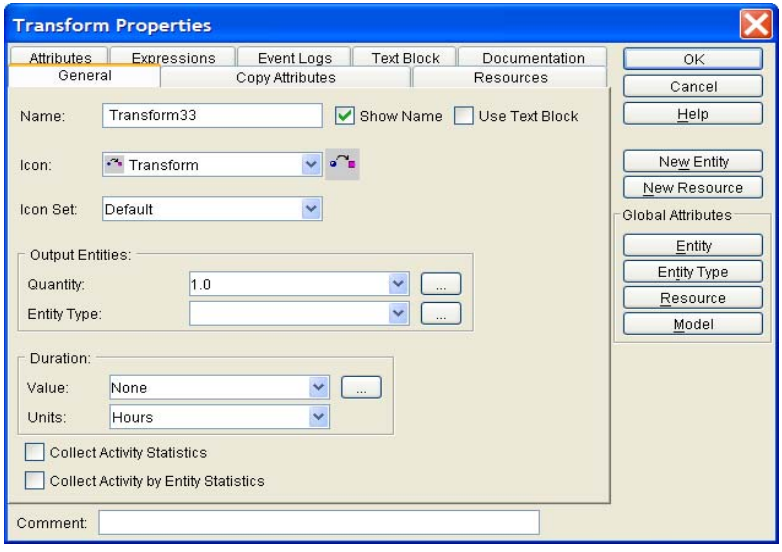
Set Attributes lists existing attribute assignments:

- Use **Add...** to set values for Entity attributes.
- Use **Edit...** to modify existing assignments. Select the attribute assignment you want to modify from the **Set Attributes** list.
- Use **Remove** to delete a previously defined assignment.

Duration is used as in other SIMPROCESS Activities.

Transform Activity

The Transform Activity changes one type of Entity into another type. A single arriving Entity can be changed into many output Entities (all of the same type.)



Dialog Field Definitions and Buttons

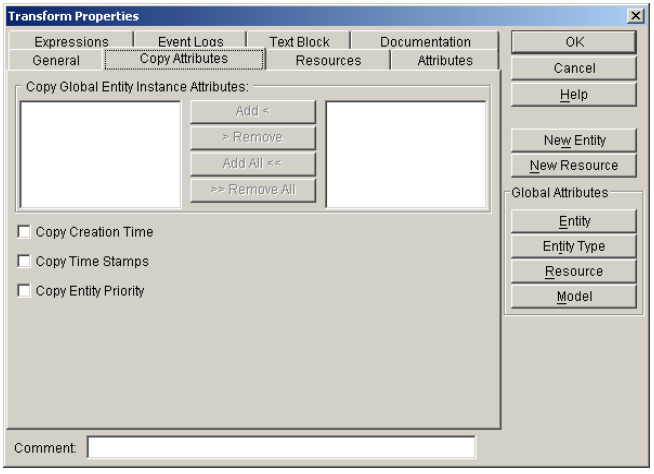
Output Entities

- **Quantity** is the number of new Entities to create. This number of each Entity arriving will be generated for *every* Connector.
- **Entity Type** is the type of Entity to be released. Select the type from the pull-down list.
- The time specified in the **Duration** will be applied before the Activity, thus it will be reflected in the Cycle Time of the incoming Entities. The outgoing Entities will not have accrued any Cycle Time.

Copy Attributes tab is where attributes of the arriving Entity can be selected to be transferred to the new output Entity. Examples of attributes that can be copied include User Defined Attribute values, creation time, etc. Time Stamps and Entity Priority can also be copied.

Specifying Attributes to Copy

Selecting the **Copy Attributes** tab displays the following:



The following options on the **Copy Entity Fields and Attributes** tab can be selected:

- **Copy Creation Time** copies the simulation creation time of the original Entity to the transformed Entities.
- **Copy Time Stamps** applies the list of predefined timestamps carried by the arriving Entity to transformed Entities.
- **Copy Entity Priority** applies the priority of the arriving Entity to transformed Entities.

The transformed Entity receives the default Priority value defined in the Entity Library unless it is copied.

User Defined Entity Attribute values associated with the incoming Entity may also be copied. During simulation, different variable types (Integer, Real, Boolean, and String) can be added to an Entity.

Click on **OK** when finished to leave the dialog, confirming your current selections. The **Cancel** button cancels the current dialog selections.

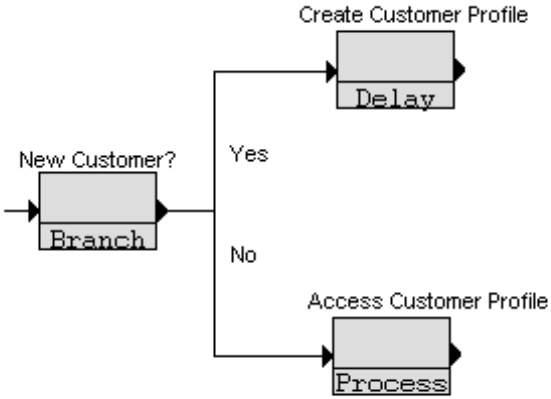
Branch Activity

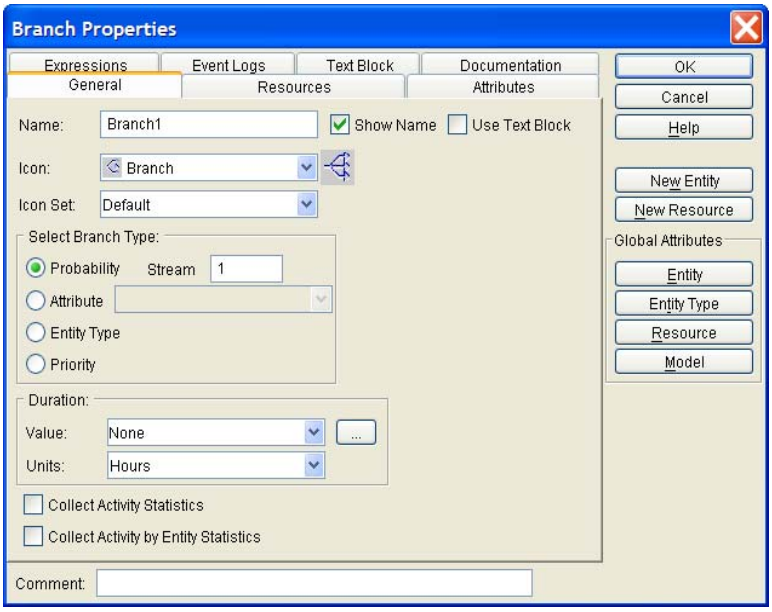
A Branch Activity routes Entities to different paths of the process model. It allows modelling decision processes, with alternative pathways selected depending on the result.

In the **Branch Activity** detail dialog, you select the type of branching criteria to use: **Probability**, **Entity Type**, **Attribute** value, or priority. The precise criteria are specified on the Connectors associated with the Branch.

Consider the case where the order fulfillment process for new customers requires a step that is not needed for repeat customers, such as creating a customer profile. Use different Entities for new customers and repeat customers and branch on **Entity Type**.

Or use a single Customer Order Entity and assume that a certain percentage of customers are new and a certain percentage are repeats. Select **Branch Type Probability** and then set the probability of each event on the Connectors leading from the Branch output Pad:





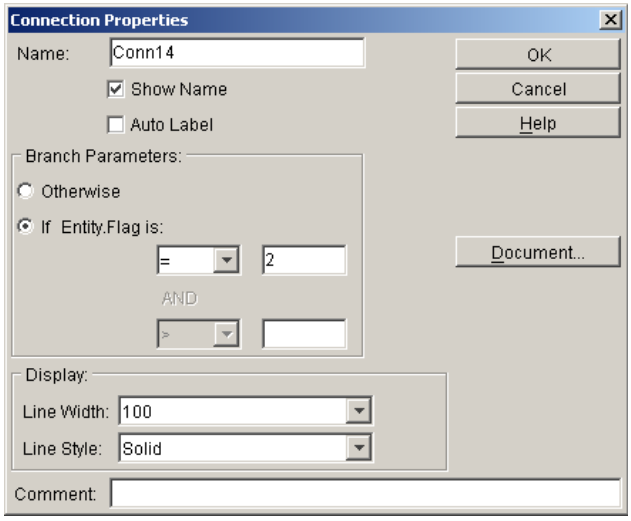
Dialog Field Definitions and Buttons

Select Branch Type

- **Probability.** Entities routed based on a probability specified on each Connector leading from the Branch. All probabilities must sum to 1.0, or one of the Connector's should have the **Otherwise** field set to **True**. **Stream** is the random number stream to use for the probabilities.
- **Attribute**. Route Entities that have matching User Defined Attributes and value along the appropriate Connector.
- **Entity Type**. Route Entities based on type, e.g., send Orders one way and Bills another. Set the Entity type on the Connectors emanating from the Branch.
- **Priority.** Ability to route higher priority items on one path, lower on another. The priorities are specified on the Connectors.

Branch Connectors

Connectors link Activities and Processes together. They are objects in their own right with information such as selection probability, user defined attributes, etc. Connector names can assist in labeling a model, e.g., the Entity type that flows. SIMPROCESS will automatically label Connectors emanating from Branch Activities. (See "Connectors and Branch Activities" on page 113 for details.)



The **Branch Connector Properties** dialog contains the **Name** of the Connector, **Comment**, the **Line Width** and **Line Style**, and **Branching Parameters**.

To display the **Connector Properties**, either double-click on the Connector, right click on the Connector and choose **Properties**, click to select the Connector and click the **Properties** button on the tool bar; or click to select the Connector and choose **Properties** on the **Edit** pull-down menu.

Connector Names

A default Connector name, e.g., Conn44 is assigned. To change the Connector Name, edit the **Name** field in the Connector properties. The **AutoLabel** check box is discussed below.

Displaying Connector Names

The **Edit Preferences** option, on the **Edit** pull-down menu, determines if Connector names are displayed in the model. However, individual **Connector** dialogs have **Show Name** check boxes that will override the model default.

The **Name** field is displayed across the middle of the Connector if **Show Name** is selected.

The **Auto Label** check box applies only to Connectors from Branch Activities. The **Name** will be generated by SIMPROCESS. SIMPROCESS uses entries in the **Connector Detail** dialog box depending on the **Entity Type**.

Connectors and Branch Activities

There are additional fields that appear in the **Connector** detail dialog box when the Connector is connecting a Branch Activity to another Activity or Process. When a Connector emanates from a Branch Activity, use the **Branch Connector Properties** dialog box to specify the branching parameters.

The corresponding **Connector Properties** are based on the type of Branch selected in the **Branch Activity Properties** dialog.

Entity Type —Select the type of the Entities that should flow along this Connector from the combo box.

Probability —Enter the probability (a number between 0 and 1.0) that the Entity will flow on this Connector.

Priority — Enter the Entity priority number to branch on. Values are from 1 to 100.

> When Entities are contending for Resources, Entities with a higher priority get to use available Resources first. The higher the number, the higher the Entity's priority.

Attribute —The first line shows the name of the attribute selected in the **Branch Properties** box. Branching can be based on the equality of numbers, strings, booleans, or on ranges of numbers. If the selected attribute is a local Entity instance or Entity-type attribute, a run time error will occur if an Entity enters that does not have the selected attribute defined.

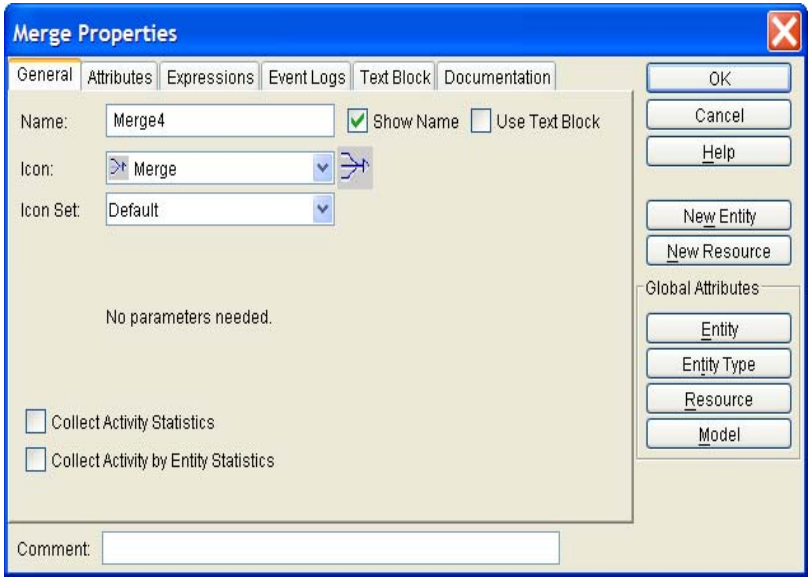
Otherwise —If **Otherwise** is selected, this Connector becomes the default branching Connector. This means all Entities pass through this Connector if none of the criteria in any other Connectors are satisfied.

Branch Activity Type	Connector Properties Used	Display Example
Probability	Probability (between 0 and 1.0) Otherwise (True or False)	0.75 Otherwise
Attribute	Branch If Attribute Is (value) Otherwise, (True or False)	Displays User Defined Attribute Name on Connector with IF or AND conditions, e.g. My Attr1 = 5, or 4 < My Attr1<7 Otherwise

Branch Activity Type	Connector Properties Used	Display Example
Entity Type	Type (from Entity type combo box) Otherwise (True or False)	Request for Quote Otherwise
Priority	Priority (Entity Priority 1-100) Otherwise (True or False)	1 Otherwise

Merge Activity

A Merge Activity routes Entities from different Connectors into one Connector. Merge can be used to TimeStamp all Entities or to reduce the number of "to and from" Connectors to create a more visually appealing model. Also, a Merge Activity is useful if groups of Activities will be copied and pasted. By using a Merge Activity, Connectors are not lost during the copy and paste.

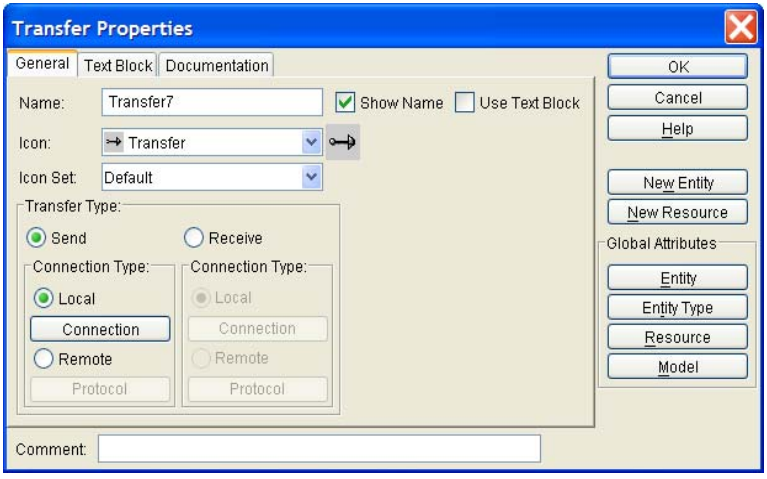


Transfer Activity

A Transfer Activity routes entities without the use of a connector. Entities can be routed within the

same model (**Local**) or to other models (**Remote**) with theTransfer Activity. (**NOTE**: Although, the **Remote** capability is discussed, this capability has not yet been implemented.) The **Transfer Type** for a Transfer activity can be **Send** or **Receive**. A sender routes entities to a receiver. Thus, Transfer Activities should be used in pairs. Every sender should have an associated receiver. A sender can only connect with one receiver, but a receiver can have multiple senders connected to it. Each **Transfer Type** designates a **Connection Type** of **Local** or **Remote**. **Local** means the entity transfer will occur within the same model. A **Send** Transfer Activity that is designated **Local** can only connect with a **Receive** Transfer Activity in the same model that has also been designated **Local**. **Remote** means the entity transfer will occur between models. A **Send** Transfer Activity designated **Remote** can only connect with a **Receive** Transfer Activity in a different model that is also designated **Remote**.

When the activity is placed on the layout, it does not have an input pad or output pad. Selecting **Send** causes an input pad to be added to the activity. Selecting **Receive** causes an output pad to be added to the activity. Once the combination of **Send** or **Receive** and **Local** or **Remote** has been set, it cannot be changed. The activity must be deleted and recreated if either option needs changing. The default combination for a new Transfer Activity is **Send** and **Local**.



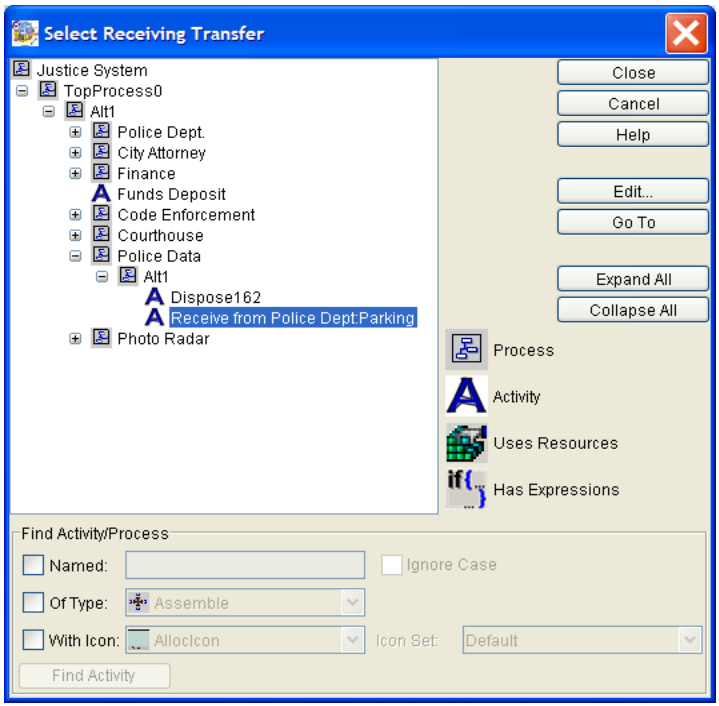
Dialog Field and Button Definitions

Transfer Type sets the Transfer Activity as **Send** or **Receive**. Both **Send** and **Receive** have a **Connection Type** (**Local** or **Remote**). The **Connection Type** options enable based on the selection of **Send** or **Receive**.

Connection Type sets the Transfer Activity as **Local** or **Remote**. The **Local** option has a **Connection** button associated with it, and the **Remote** option has a **Protocol** button associated with it. The **Connection** button is active when **Local** is selected, and the **Protocol** button is active when **Remote** is selected.

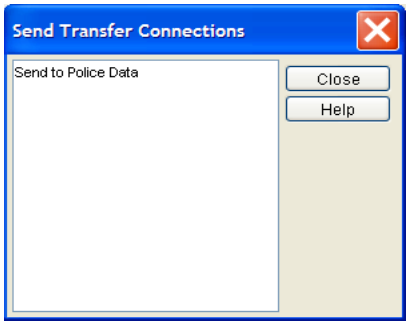
The **Connection** button for the **Send** option operates differently from the **Connection** button for the

Receive option. Clicking the Connection button associated with Send/Local brings up a modified version of the Activity Browser dialog. (See "Activity Browser..." on page 27 for more information on using the Activity Browser.) This version includes a **Cancel** button.



All the functions of the dialog are the same as the Activity Browser dialog. Select the receiving Transfer Activity. (The **Find Activity/Process** section of the dialog can be used to search for Transfer activities.) The activity selected when **Close** is clicked must be a Transfer Activity with **Receive** and **Local** selected. An error will occur if the activity selected is not a Transfer activity with **Receive** and **Local** selected. Click **Cancel** to not make a selection or to keep the current selection. Although the selection of **Send** or **Receive** and **Local** or **Remote** cannot be changed once selected, the **Connection** can be changed once set.

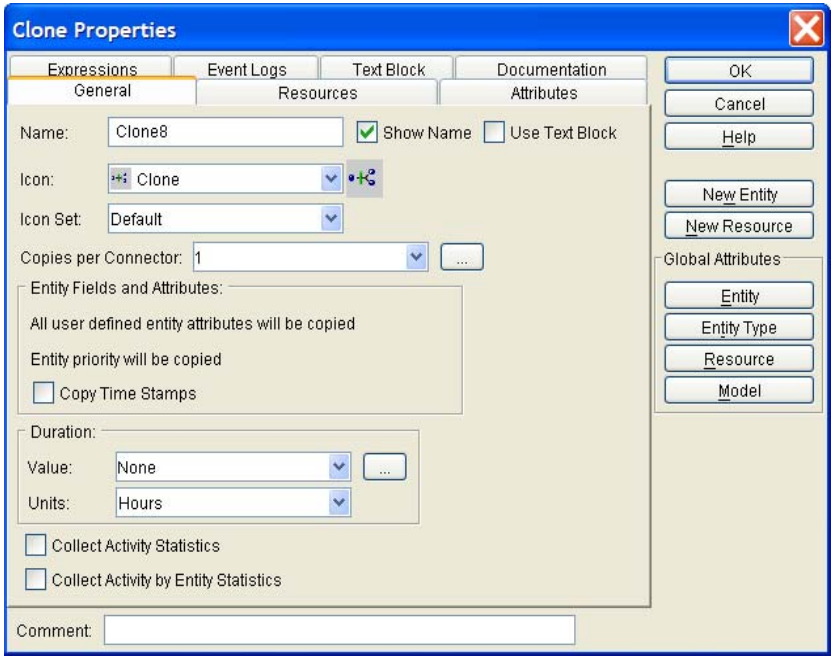
The **Connection** button associated with the **Receive** option displays a list of the **Send** Transfer Activities routing entities to that **Receive** Transfer Activity. No editing of the connections is allowed. The dialog is for informational purposes only.



The **Protocol** buttons will set the sending and receiving protocols for **Remote** transfers when the **Remote** capability is implemented.

Clone Activity

The Clone Activity generates duplicate Entities. Note that this activity is only available from the **Create** menu. This is because the Clone activity exists primarily to support pre-SIMPROCESS version 4.0 models. Since the cloned entities leaving the Clone activity are of the same type as the entity entering the activity, the entity statistics for the type of the entering activity are affected by the creation of the cloned entities. The entity statistics are skewed by the Clone activity. The Split activity is the recommended activity for entity cloning since the cloned entity can be a different type of entity. Thus the statistics for the original entity are not affected by the creation of cloned entities.



Dialog Field Definitions

- **Number of Copies per Connector** is the number of Entities that will come out the Clones Pad into *each* Connector.
- If a **Duration** is defined for the Activity, the time specified in the **Duration** will be applied before the Activity. In other words, it will be reflected in the Cycle Time of the incoming Entities.
- If Time Stamps are defined for the incoming Entity, those values can be passed to the Clones by selecting **Copy Time Stamps**.

Split and Join Activities

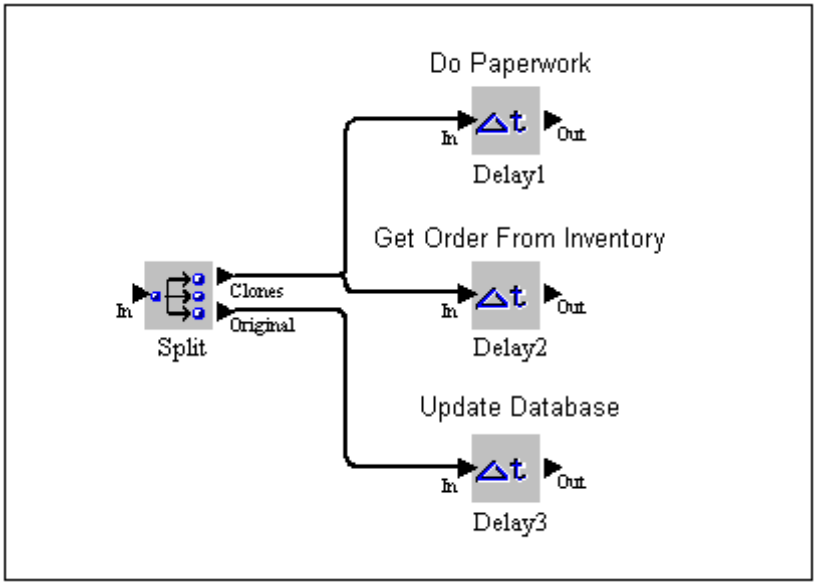
The *Split* and *Join* Activities work together to temporarily split the processing of an Entity among parallel Activities.

At the Split Activity, an Entity is converted into two or more Entities, each of which follows a different path before (optionally) reuniting at a Join Activity.

The Split Activity generates *child* Entities from the *parent* Entity. The children and the parent Entity belong to the same *family.* After going their separate ways, the family is reunited at the Join Activity,

where a single Entity, the *parent*, exits for continued processing.

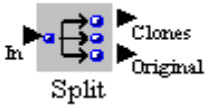
In the order fulfillment process, Split and Join might come into play in the handling of rush orders. To speed up processing of rush orders, the work might be divided among several clerks at some point:



The figure above shows how a Split Activity takes a customer order Entity and releases three Entities, the original and two children (or clones). Each Entity goes to a different Activity, where a different task is performed on the order.

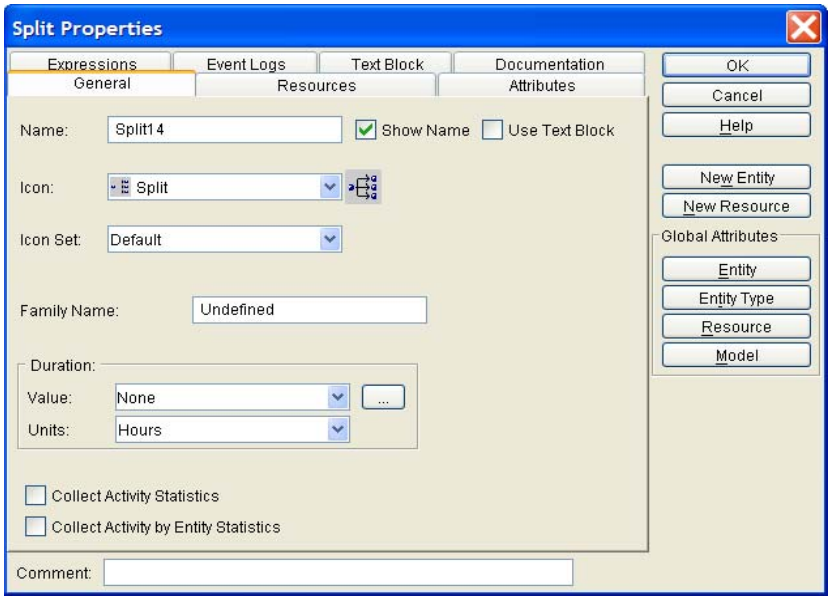
Defining a Split Activity

When you add a Split Activity to the SIMPROCESS layout, it has one input Pad and two output Pads attached:



The upper output Pad is named *Clones*; the lower Pad is named *Original* (if you double-click on the Pads, you will see their names in the **Pad Detail** dialog).

Use the Original Pad to route the original Entity to the next Activity in its path. Use the Clones Pad to route each of the split Entities to their next Activities. An unlimited number of split Entities of different Entity types can be released at a Split Activity, but all Entities emerge from the same Pad.



Dialog Field Definitions

The unique attribute of the Split Activity is:

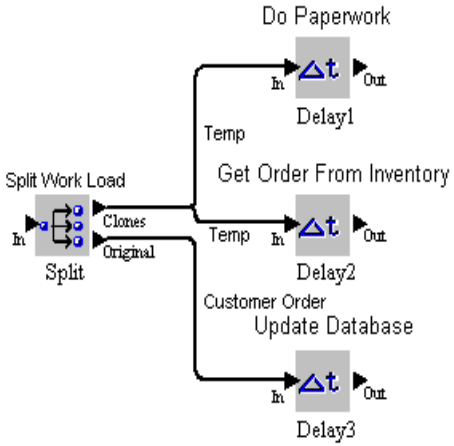
Family Name. This names the family of Entities being created. The original Entity and its children can be identified by their common family name. **Family Name** is used at a Join Activity to identify the Entities to be joined. Family names must be unique within a model.

Identifying Split Entities

Split Entities are Attributes of the Connector: a Split Entity is defined for each Connector linking a Split Activity to a connecting Activity.

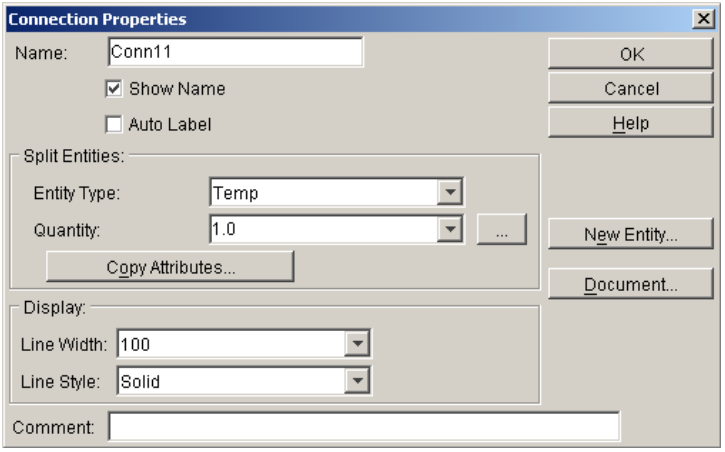
A single Connector is drawn from the *Original* output Pad to an adjoining Activity's input Pad. Then, the *Split* output Pad is connected to the other adjoining Activities.

As an example, the figure below shows the distribution of rush order processing into three simultaneous Activities: paper work, retrieval of an item from inventory, and updating of the inventory database.



The *Original* Pad of the Split Activity is connected to the input Pad of the *Update Database* Activity, so the original customer order Entity flows through *Update Database*.

Double-clicking on one of the Connectors emanating from the Split Pad opens the Split Connector properties.



Dialog Field Definitions

The unique attributes of the Split Connector are:

- **Entity Type** is the field where the Split Entity type that will flow along this Connector is selected.
- **Quantity** specifies how many of the split Entities will flow along this Connector for *each* original Entity that enters the Split Activity.
- **Copy Attributes** opens a dialog where Global Entity Instance attributes to copy from the original Entity to each of the Split Entities are selected. Entity Priority and Time Stamps can also be copied from the original Entity to each of the Split Entities.
- **New Entity** button opens the Entity definition dialog for modifying Entity-type definitions.

Clicking on the **Entity Type** pull-down box displays a list of the Entities in the model. The Entity to flow along this Connector is selected here.

For analysis purposes, consider using a different name for the children. For example, if the original Entity type *Customer Order* is used for each of the paths leading from the Split Activity, distortions in the statistics for the *Customer Order* Entity could occur. When all split Entities meet again at the Join Activity, the two split Entities are destroyed at the Join, while the original Entity continues on. When total cycle time for *Customer Order* Entities is calculated at the end of a simulation, those split Entities skew the statistics.

Cycle times for the split Entities are measured from generation in the Split Activity to termination in the Join Activity, while the original Entity's cycle is measured from a Generate to a Dispose Activity.

An Entity named *Temp* is defined and used on the Split Connectors in the case of Rush Order Processing in order not to skew the cycle time or Entity count statistics for Customer Order Entities.

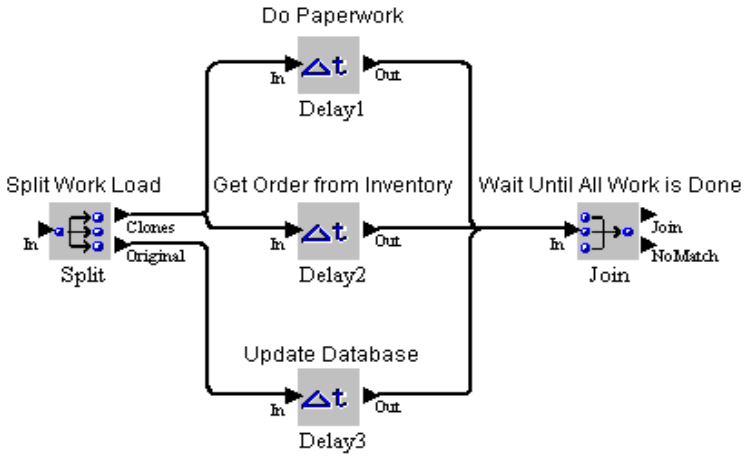
Note that using an Entity named *Temp* for split Entities is adequate if the simulation statistics of these Entities is not important. Define a different Entity type for each Split path if the number of each split Entity generated during a simulation is important, or any other Entity statistic is important.

Select the **Auto Label** option if you want SIMPROCESS to display the Entity name on the Connector. The name will be displayed unless **Show Name** on the Connector is turned off.

Click on **OK** when you finish defining the Connector.

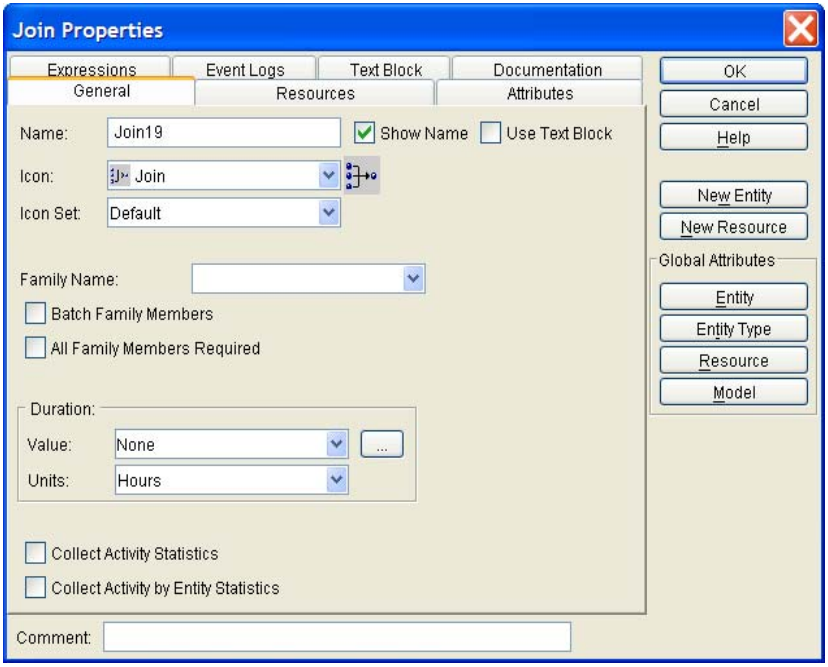
Defining a Join Activity

Entities released from a Split Activity are reunited at a Join Activity.



The Join Activity icon has one input Pad and two output Pads. The upper output Pad is named *Join*; Entities that are reunited with their family exit through this Pad. The lower Pad is named *NoMatch;* Entities that are not members of the Join family leave through this Pad.

An Entity that is not a member of the Rush Order family that enters the Join Activity will pass through the Join Activity and exit through the NoMatch Pad. No processing time will apply even if a delay duration is specified.



Dialog Field Definitions

Family Name identifies the Entity family to be joined. The pull-down list for **Family Name** contains the names of all families that have been defined in the model. Family names do not have to be unique in Join Activities, i.e., two Join Activities could use the same family name. This would be done if the same split Entities needed to be joined twice. The exiting Entity could be a batch that could be later unbatched and joined again after further processing.

Batch Family Members tells SIMPROCESS to batch the child Entities with the original Entity. The Entity could be separated into its components at an Unbatch Activity. Otherwise, all the child Entities are disposed in the Join Activity. SIMPROCESS releases the original Entity through the *Join* Pad.

By default, **All Family Members Required** is not selected. When the original Entity enters a Dispose Activity or is otherwise destroyed before it reaches a Join, SIMPROCESS releases one of the child Entities at the Join Activity. Which child Entity is released cannot be specified; SIMPROCESS selects it.

Note that if any of the child Entities are disposed before they reach their Join Activity, the rest of the family still reunites at the Join; if the rest of the family is already at the Join Activity at the moment the child Entity is destroyed, SIMPROCESS processes and releases the original.

If **All Family Members Required** is selected, then no Join will occur until all family members (children and parent) arrive at the Join Activity. Thus, if any members of the family are disposed before the Join, then the remaining family members will remain queued in the Join Activity.

CHAPTER 5

Resource Modeling Constructs

A Resource is an agent that is required to perform the tasks associated with an activity. People, equipment, vehicles, money, and space can be modeled as Resources. The limited availability of Resources is an important constraining factor in business processes.

- A bank customer requires the help of a loan officer in order to submit a loan application.
- On a manufacturing line, a computer board cannot be populated with chips unless both an operator and a surface mounting tool are available.

The loan officer, the operator, and the surface mounting tools are Resources whose availability affects the activity in these examples.

SIMPROCESS provides the means for modeling Resources and for measuring the impact on the performance of a business process. In addition, variable and fixed costs associated with Resources may be used to measure Process costs and activity costs. See Chapter 7, “Activity-Based Costing,” beginning on page 153 for more details.

This chapter describes how to:

- Define Resources
- Define groups of Resources for complex Resource requirements
- Define the Resource requirements of activities
- Use Resource related activities such as: Get Resource, Free Resource, and Replenish Resource.

Resources and Simulation

When an Entity arrives at an activity, SIMPROCESS checks to see if any Resources are required to process it. If Resources are required, SIMPROCESS attempts to obtain them. Once an activity gains control of one or more units of a Resource, those Resource units are unavailable to any other activity. The activity retains control of the Resource units until it finishes Processing the Entity.

Resource Allocation Policy

During simulation, many activities may simultaneously contend for units of the same Resource. If a required Resource is not available when an Entity arrives at an activity, the Entity waits for that Resource in a queue. This state is defined as “Wait for Resource” in the SIMPROCESS Standard Report.

If an activity requires units from two different Resources and units from only one Resource is available, SIMPROCESS may or may not obtain the Resource units that are available. It depends on the rules defined for the model. Any Resource units an activity holds are unavailable to other activities.

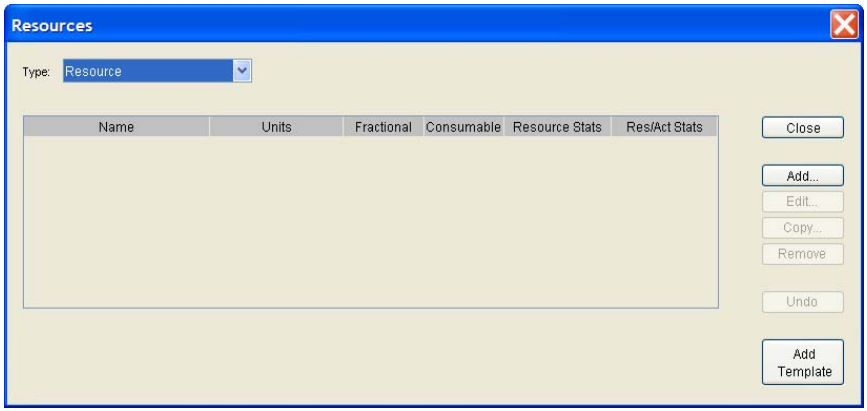
SIMPROCESS attempts to satisfy Resource requirements in the order of the priority of Entities queued for the Resource. Priority is an Entity attribute assigned when the Entity is defined. All Entities with the same priority are treated on a first-come, first-served basis. A higher priority Entity may (optionally) preempt a lower priority Entity when the Resource units needed are not available. See “Preempting Lower Priority Entities” on page 139.

Defining Resources

Use the **Resource** option from the **Define** pull-down menu, to define Resources in a model.

In the following discussion, Resources for an order distribution Process will be used: sales representatives to Process the orders, trucks to deliver merchandise, and fuel to power the trucks.

1. On the **Define** pull-down menu, select **Resources...**



The **Resources** dialog is used to define new Resources, modify existing Resource definitions, copy Resource definitions, or delete Resources. The **Add** function creates a new Resource definition. The **Edit, Remove**, and **Copy** functions are only active if there are existing Resource definitions. These functions operate on the Resource selected in the table:

Edit modifies an existing Resource definition.

Remove deletes a Resource definition.

Copy creates a new Resource based on the definition of an existing one.

Type specifies the Resource template that will be used to create a new Resource definition.

Undo restores a Resource that has been removed.

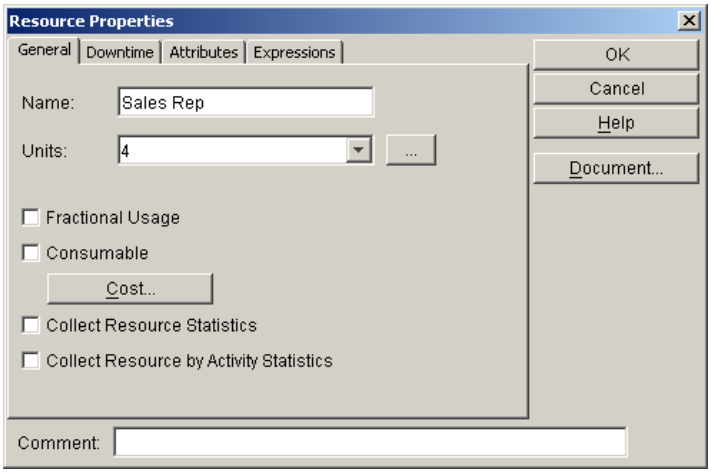
Add Template saves the Resource definitions for re-use. Templates are discussed in "Adding Resource Templates," beginning on page 204.

SIMPROCESS has one Resource type pre-defined which can be used when defining a new Resource. New Resource templates can be created and added to the **Type** list. (See "Adding Resource Templates," beginning on page 204 for more information on Resource Templates.) When the **Add** button is chosen, a new Resource with the characteristics of the **Type** selected will be created. The pre-defined type is a default Resource:

- One unit of resource.
- No downtime defined.
- No costs defined.
- No Attributes or Expressions defined.

See "Resource Downtime," beginning on page 294 for more information on Resource Downtime.

Click on **Add** to define a new Resource:



On the **Resource** dialog **Name** is any unique name identifying the Resource. Define the sales clerk staff, and name the Resource *Sales Rep*.

NOTE

Special characters, such as "/", "+", single quotes, or "-", should not be used in the **Name** of a Resource. This adversely impacts statistics and cost data collection.

Units identifies the initial capacity of the Resource. If the Resource is not consumable, capacity is constant throughout the simulation. If the Resource is consumable, capacity will vary over the length of the simulation. This fluctuation in capacity will be reflected in the capacity statistics in the Standard Report. Number of **Units** of a Resource can also be specified with a single line Expression, or a User-defined Attribute. See "Variable Resource Usage," beginning on page 224 for more information.

Fractional Usage indicates whether or not fractional units of the Resource can be allocated. If this box is checked, a non-integer value for **Units** (e.g., 2.5, 10.2) may be defined. It also means that an activity can acquire a fractional part of the Resource.

Consumable is used to identify resources that cannot be released and reused later, such as paper or oil. They must be replenished before demand is greater than supply.

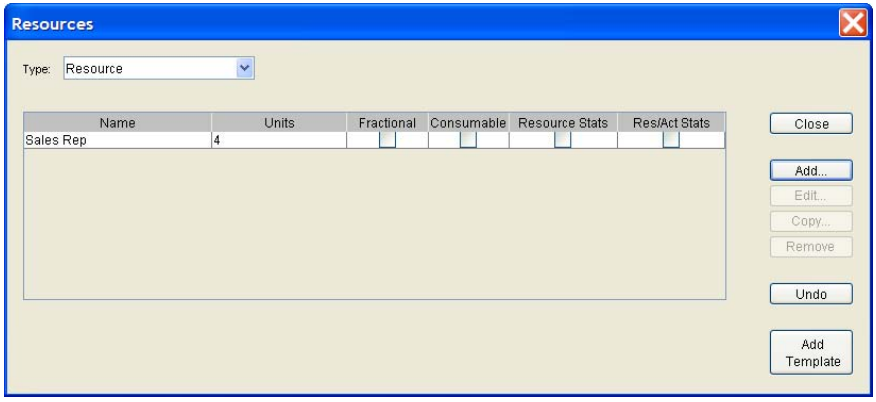
The **Cost** function allows cost values to be assigned to Resources and keeps track of the expense involved in using Resources. This function is described in detail in Chapter 7, “Activity-Based Costing,” beginning on page 153.

Expressions tab provides the means of writing specialized Processing instructions.

The **Attributes** tab defines attributes for the Resource. Attributes are customized variables. Typically, expressions include Processing of attributes. These topics are discussed in depth in Chapter 10, “Customizing a Model with Attributes and Expressions,” beginning on page 210.

The **Document** function is used the same way it is for Activities, to store descriptive text about the Resource. The default headings can be customized. (See “document Subdirectory” on page 422.)

The **Downtime** tab is where the periods when the Resource will *not* be available in the model are defined. Resource downtimes are described in “Defining Downtime Schedules of Resources,” beginning on page 298

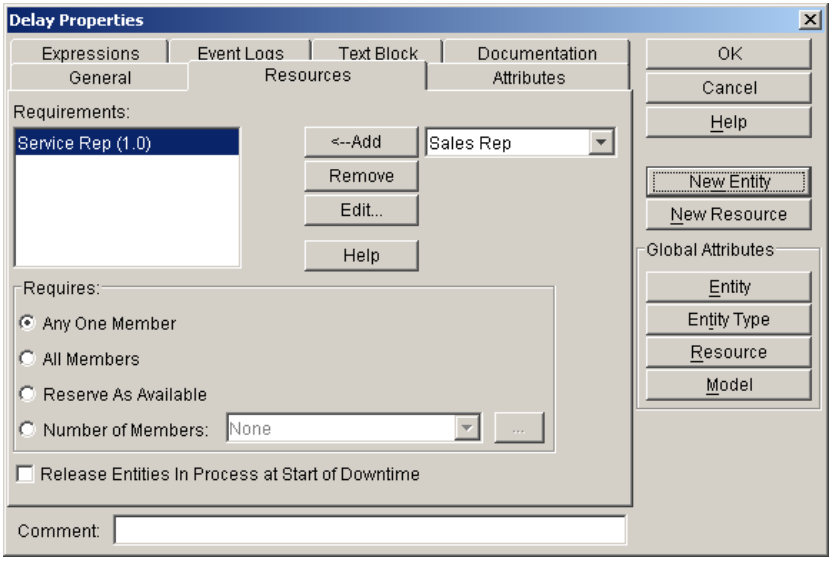


Note that the basic properties of Resources added to the model can be edited directly from the table. However, changes made in the table are direct changes to the properties of the Resource and cannot be canceled. Also, the table can be sorted by a particular column by clicking on the column header. Holding the **Shift** key while clicking on a column header causes the table to sort in the reverse order.

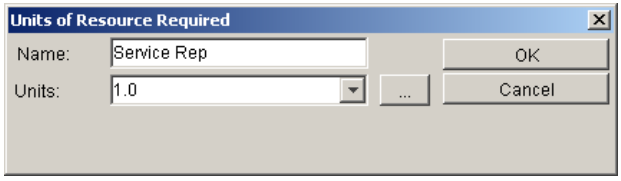
Adding Resource Requirements to Activities

Once the model flow and resources are defined, the Resource requirements of each Activity must be added to the model.

The Resource requirements for an activity are defined by double-clicking on the activity's icon to display the **Activity Properties** dialog box. On the dialog box, click on the **Resources** tab:



Add adds an individual Resource requirement for the activity. The units required default to 1.0 when a Resource is added. Use **Edit** to modify an existing requirement definition.



Any existing resources will be listed under the **Requirements** heading. Highlight the resource allocation to be modified, and press **Edit**. Units may be a constant or a distribution. Resource requirements can also be set by using the **Evl** function with User-defined Attributes. See "Variable Resource Usage" on page 224.

If the units requested are larger than the defined capacity of the Resource and the Resource is not a consumable Resource, a runtime error will occur. However, if the Resource is a consumable Resource, the Entity will remain in the wait for Resource queue. Entities remain in the wait for Resource queue until the consumable Resource has been replenished to a level at or above the required allocation.

Remove deletes the requirement highlighted in the **Requirements** box.

Once a list of Resources has been chosen for the activity, the combination of Resources in the **Requires** area may be specified.

Requires defines the combination of Resources required to perform this activity:

- **Any One Member** — any one of the Resources listed is sufficient to perform the task.
- **All Members** — all members in the **Requirements** list are needed in order for this activity to Process an Entity. SIMPROCESS does not obtain any member until all the required Resources are available.
- **Reserve As Available** — all listed Resources are required and will be reserved as they become available.
- **Number Of Members** — A certain number of members of the list (but not all members) are needed to Process an Entity. Enter the value of number in the box.

> **Reserve As Available** may pose a risk of deadlock.
>
> Activities A and B are both defined as requiring Resources 1 & 2, using **Reserve As Available** logic. An Entity arrives at activity A, which obtains Resource 1. Resource 2 is not available, so A waits for it.
>
> Now an Entity with higher priority arrives at Activity B. Activity B waits for Resources 1 and 2. Then Resource 2 becomes available. Although Activity A has been waiting for Resource 2 longer than Activity B has, B gets the Resource because the Entity it is processing has a higher priority than Activity A's Entity. A deadlock develops since neither activity will release the reserved Resource. Make sure this situation cannot develop.

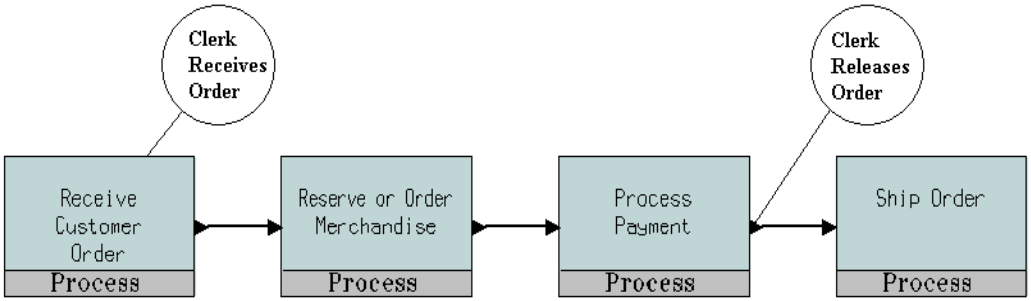
Release Entities In Process at Start of Downtime sets whether Entities are released when Processing is interrupted by Resource downtime. This option is not available on the Resource usage dialog of the Get Resource activity. This is because Get Resource activities have no delay for Processing. See "Defining Downtime Schedules of Resources" on page 298.

Explicitly Getting and Freeing Resources

When an Entity arrives at an activity, if a Resource is listed in the Resource requirements list for the activity, SIMPROCESS attempts to obtain the Resource required to process the Entity. If the required Resource or Resources are not available, the Entity waits until the Resources become available. When processing is completed, the activity releases the Entity and frees the Resources.This is an implicit way to get and free a Resource. However, some business processes require more control over resource allocation. The Get Resource and Free Resource options allow the model to explicitly control the allocation of Resources.

A clerk may perform a series of activities, and it is necessary that the same clerk execute all the activities in a given order. Therefore, the model should "Get" the Resource, perform all the activities and then "Free" the Resource. The remainder of the section will describe how to model this series of actions with SIMPROCESS.

.



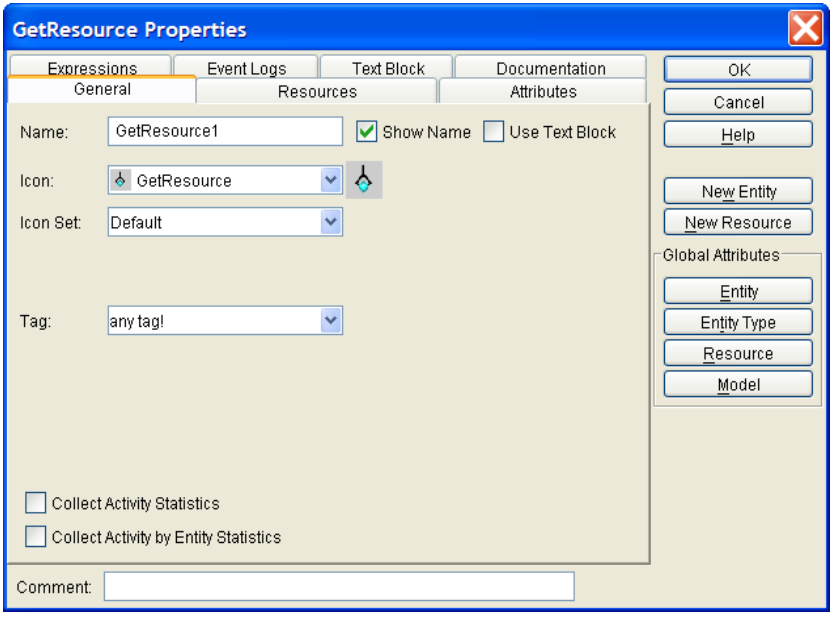
Get Resource and Free Resource Activities

Get Resource Activity

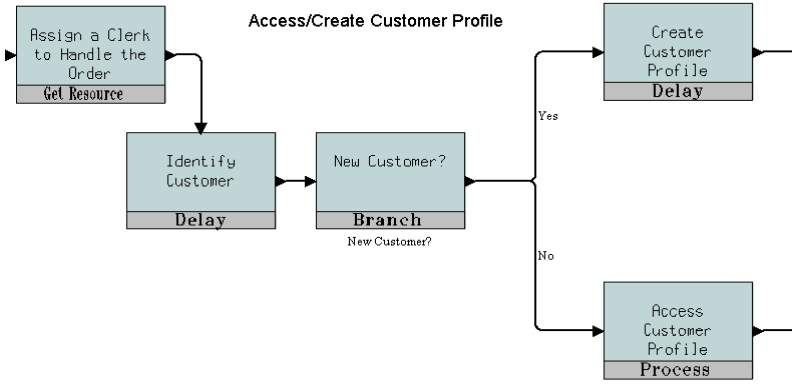
The **Get Resource** activity obtains a Resource and holds on to it across multiple Processes and activities.

Assign a unique **Tag** to each **Get Resource** activity. Although it is possible to use the same **Tag** twice at different levels of the model hierarchy, it is highly discouraged.

In the **Get Resource Activity Properties** dialog, click on the **Resources** tab to specify the Resources to be allocated. Fill out the **Resources Usage** dialog as specified in “Adding Resource Requirements to Activities” on page 131.



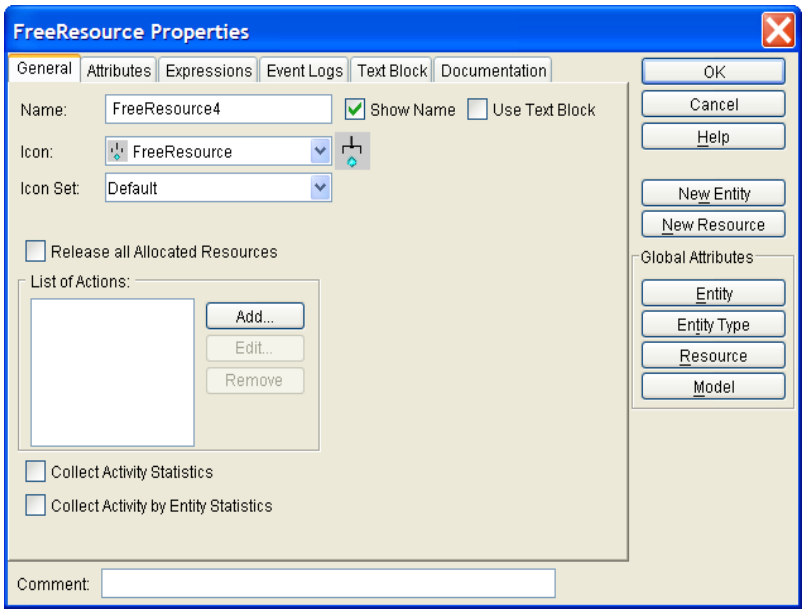
The *Access/Create Customer Profile* Process is shown with a Get Resource activity added:



Get Resource obtains Resources that would otherwise have been obtained in the ensuing activities. Do not define the same Resource requirement in those activities as well.

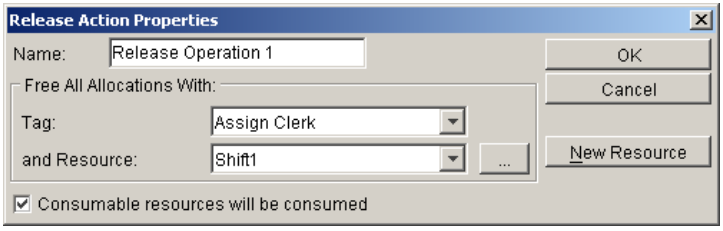
Free Resource Activity

The **Free Resource** activity is used to release Resources obtained at a **Get Resource** activity.



All Resources that have been allocated for this Entity can be freed by clicking on the **Release all Allocated Resources** box.

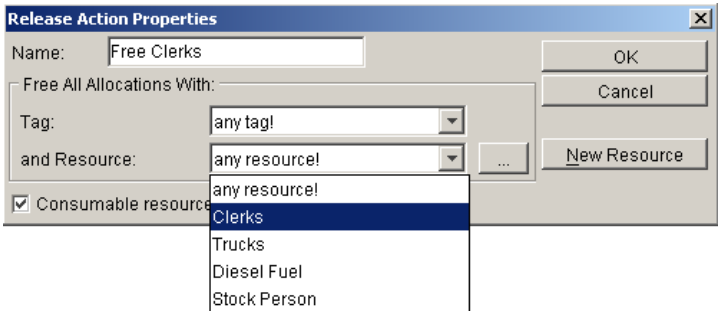
An explicit set of Resources to be freed can be defined by clicking on the **Add** button in the **FreeResource Activity Properties** dialog box. The **Add** button brings up the following dialog.



Assign a **Name** to the action being defined. This name will be displayed in the **List of Actions** field of the **FreeResouce Properties** dialog box.

The **Tag and Resource** fields combine to define free Resource actions:

1. **Tag** indicates the **Get Resource** activities whose Resources will be released. The pull-down list contains all the **Get Resource** tags in the model.



   A tag may be selected from the listbox, or **any tag!** may be specified, which causes the free action to ignore the tag assigned at the Get Resource activity.

   If more than one Get Resource activity was used, separate free actions can be defined for each set of Resources to be freed.

2. Use the **Resource** pull-down list to specify the Resource being freed, or select **any Resource!** to free all Resources allocated for the Entity. Resources are only freed if they were obtained in the activities specified in the **Tag** field.

   To release more than one Resource, but not all the listed Resources, create a separate action for each.

3. Select **OK** to accept the definition. The action now appears in the **List of Actions** schedule.

You can add additional actions to the list by clicking on **Add** and defining the action.To modify the definition for an action item, highlight it in the listbox and click on **Edit**. To remove the action, click on **Remove**.

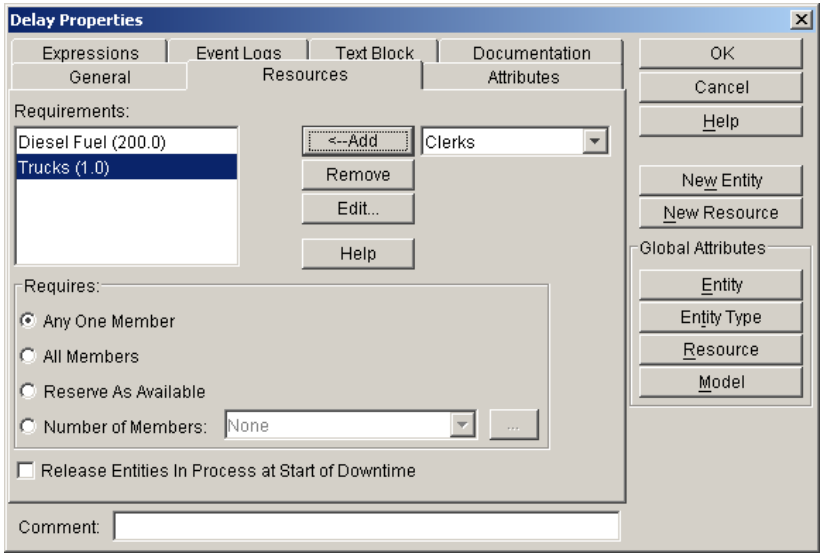
SIMPROCESS provides the option of whether or not to deduct the amount acquired from consumable Resources when those Resources are freed. Click on the **Consumable Resources will be consumed** check box in order to decrement consumable Resources. For example, a **Get Resource** activity obtains 50 gallons of Diesel Fuel in anticipation of shipping merchandise to a customer. Before reaching the shipping activity, the Entity enters a branch node in which the merchandise order is canceled. In this situation, one branch of the path leads to a **Free Resource** activity where the consumable Resource is not consumed, since it was not used. The other path continues on to the shipping activity, and then to a **Free Resource** activity in which the fuel Resource is consumed.

Getting and freeing Resources can also be accomplished using expressions. See “Getting and Freeing Resources Using Expressions” on page 253.

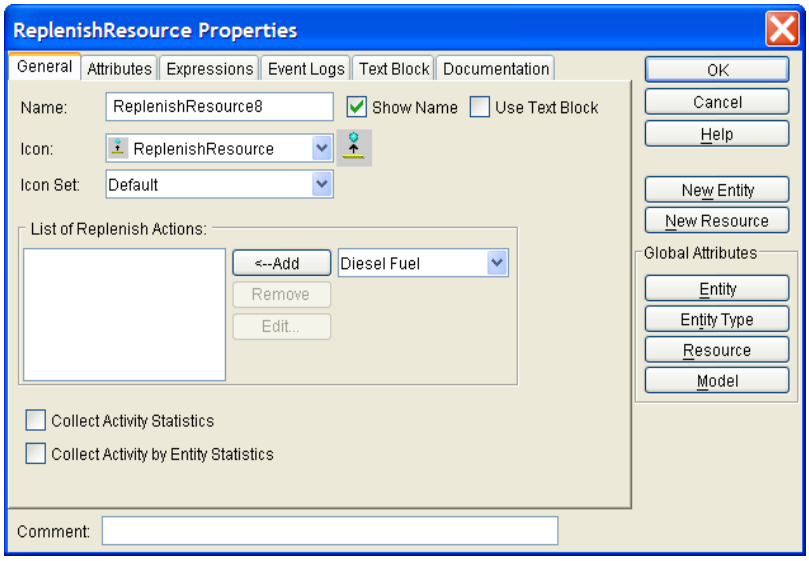
Replenishing Consumable Resources

The **Replenish Resource** activity is used to replenish a consumable Resource during a simulation.

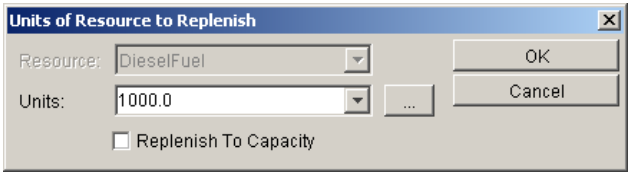
Diesel fuel is a consumable resource used when shipping merchandise. Once an order is made, the truck and a quantity of fuel will be allocated as Resources to perform the shipping. The fuel quantity is deducted from the inventory and gets replenished by a daily shipment received each morning.



Double-click on the **Replenish Resource** icon to define this action.



Select the consumable Resource on the drop down menu, and then click on **Add** to define a replenish action:



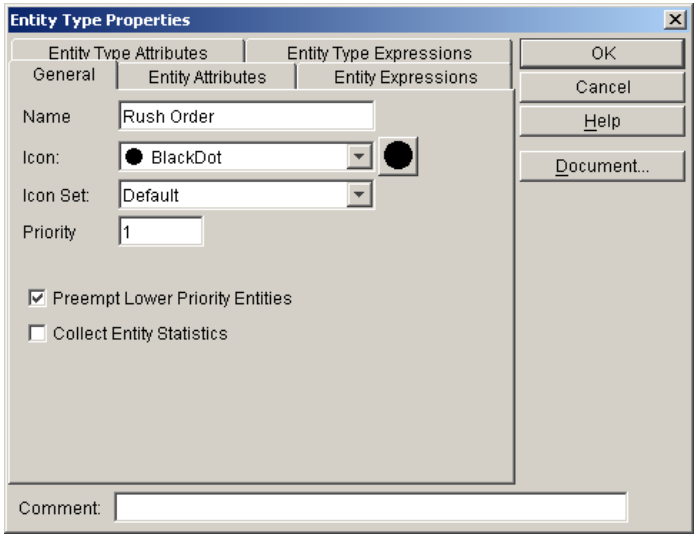
The **Resource** field identifies the Resource to be replenished. The pull-down list shows all the consumable Resources defined in the model.

Units indicates the quantity of the Resource to be added either in a real number or a statistical distribution. The distribution can be selected from the pull-down list of the **Units** field. The **Replenish to Capacity** box indicates that a Resource should be replenished only up to the value specified in its **Units** field when the Resource was defined.

Note that Resources can also be replenished using expressions. See "Changing Resource Capacity With Expressions" on page 256.

Preempting Lower Priority Entities

A higher priority Entity may preempt a lower priority Entity when the Resources are not available. Selecting Preempt Lower Priority Entities on the Entity definition dialog will potentially cause all Entity instances of this type to interrupt Activities processing lower priority Entities.



In this example, if a Rush Order Entity enters an activity that requires Resources, and no Resources are available, SIMPROCESS will check the Entities being processed. If there is a lower priority Entity Processing, the Processing will stop and the Resources will be released. When the Processing is stopped, if the **Interrupt Processing** Entity instance expression has statements, it is executed. The Rush Order Entity obtains the Resources and starts Processing. The Entity that was interrupted goes back to the wait for Resource queue. It will be placed in the queue ahead of all other Entities with the same or lower priority. When the interrupted Entity obtains Resources again, it will Process with the time that was remaining when it was preempted. Also, if the **Resume Processing** Entity instance expressions has statements, it is executed. (See page 247 for information on Entity instance expressions.)

CHAPTER 6

Graphical Modeling Constructs

Graphical constructs in SIMPROCESS include:

- Background Text (static and dynamic)
- Background Graphics

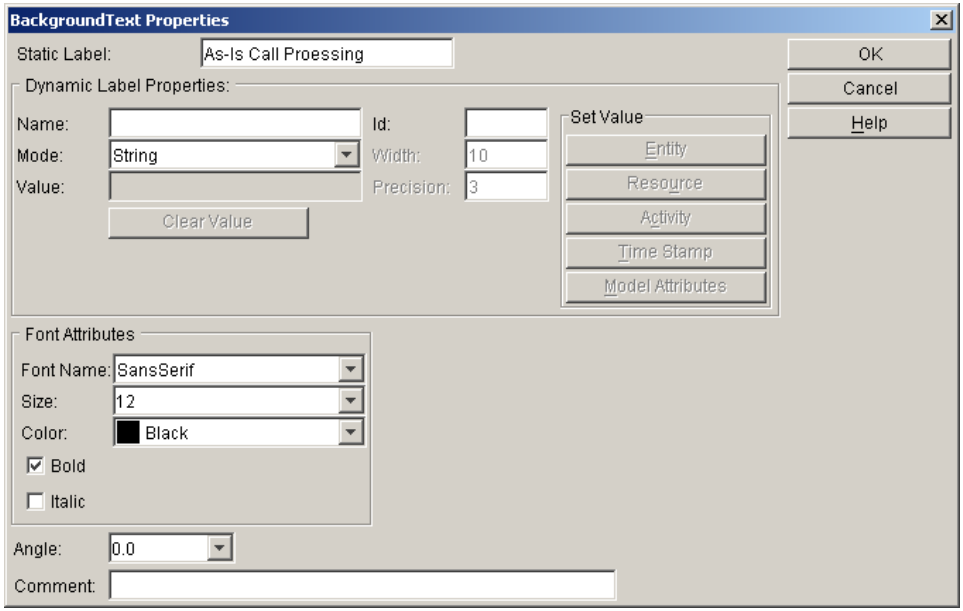
In addition, graphics can be imported for use as backgrounds or icons, and animation can be recorded for playback.

Background Text

There are two types of background text in SIMPROCESS: static text and dynamic labels. Static text is used for annotating the model layout and does not change during simulation. Dynamic labels are updated during simulation and are used to display information about changing properties of model elements. Several text labels can be grouped together on the layout and their horizontal and vertical alignment can be set using the **Align** option.

Dynamic labels can be updated automatically or by using the SIMPROCESS Expression Language. The SIMPROCESS Expression Language is an advanced feature found in SIMPROCESS Professional. Updating dynamic labels using expressions is covered in Chapter 10–Customizing a Model with Attributes and Expressions. This topic begins on page 210.

Properties are specified in the **Background Text** dialog, invoked by selecting a text tool from the palette (marked by a capital T) and clicking on the background in the location where text is to be placed. Text can be moved by clicking and dragging. The following shows a static label. Note that the **Static Label** field and **Font Attributes** are all that are required for a static label.



The dialog is divided into two sections: the top group of controls, designated as **Dynamic Label Properties,** is only applicable to dynamic text; the bottom group — **Font Attributes** — is used to specify all text properties. Defaults for the **Font Attributes** can be set on the **Background**

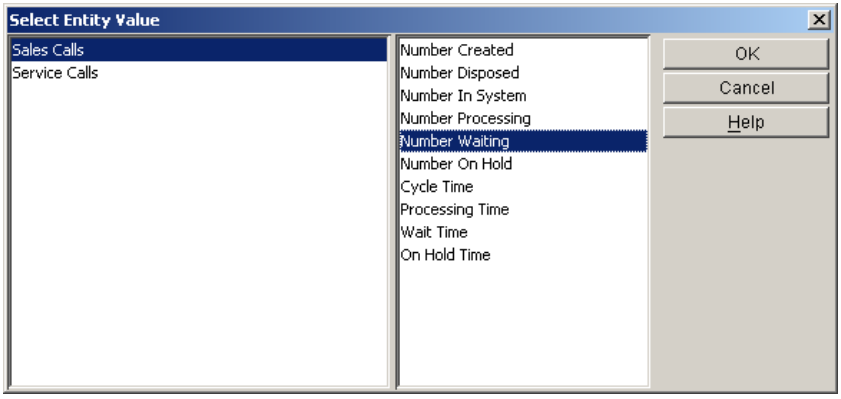
Text tab of the Preferences dialog (**Edit/Preferences**).

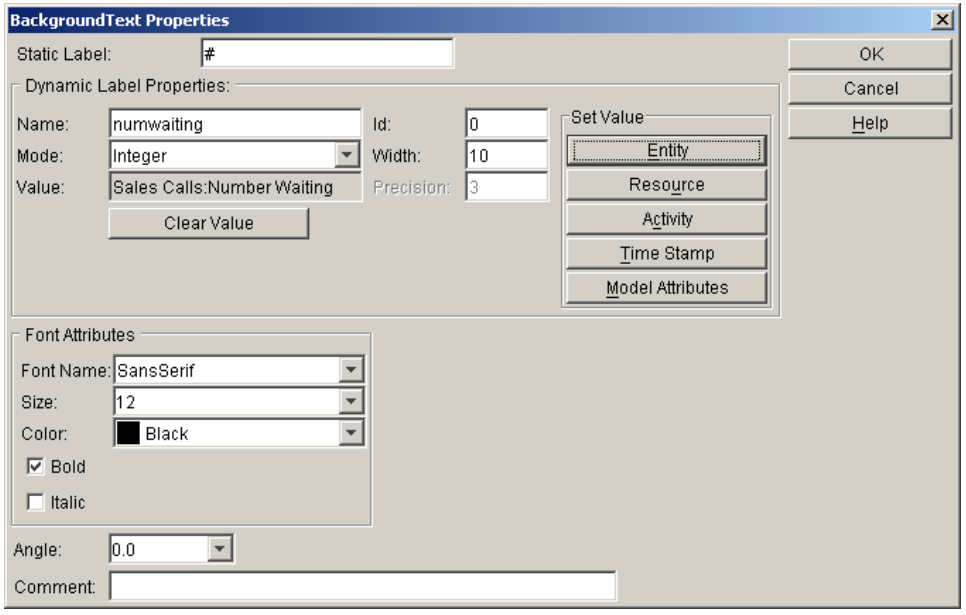
SIMPROCESS provides a list of the available fonts. Some fonts will not properly display their names in the combo box if the Java environment is unable to handle them. Avoid using these fonts. All rotation settings in the **Angle** combo box can be used with any font settings. Note that once the text is placed on the layout, the selection box around it has no handles. The only way to resize font text is to change its point size in the **Fonts** dialog. Once the text is placed on the layout, it can be moved, its properties edited, and it can be grouped with other objects on the layout.

If a dynamic label is placed on the layout, in addition to its font attributes, appropriate information needs to be entered in the **Dynamic Label Properties** group. Each dynamic label must have a unique combination of **Name** and **Id** number. Usually, **Id** number will be 0, unless two dynamic labels have the same name. The name typed into the **Name** text box will not appear on the layout. It will only be used to reference the label. Also, choose the type of value with which the dynamic label will be updated. The choice between String, Integer, and Real is made in the **Mode** combo box. If the value of the dynamic label is Real, also specify **Width** and **Precision** in the corresponding value boxes. **Width** is the total number of digits that will be shown for the displayed value (including the decimal point), while **Precision** specifies the number of digits after the decimal point that will be displayed. If the **Width** is greater than the value being displayed, it will be padded with spaces on the left side. If the **Mode** is Integer, then only the **Width** field needs to be set.

The **Value** field can be left empty. If so, the dynamic label can only be updated by using the SIMPROCESS Expression Language (page 258). Likewise, if the **Mode** is String, the dynamic label can only be updated through the SIMPROCESS Expression Language. If the **Value** field is not empty, the dynamic label will update automatically every time the selected value changes. The five buttons to the right (**Entity**, **Resource**, **Activity**, **Time Stamp**, and **Model Attribute**) are used to set the **Value** for the dynamic label. These buttons are active when a valid **Name** and **Id** has been entered and the **Mode** is not String. Each button brings up a dialog that lists each model element of that type (Entity, Resource, etc.) on the left. Once a value is selected on the left, the values available are listed on the right. Only one item can be selected on each side.

Selecting the **Entity** button displays the following dialog.





The **Value** field can be changed by selecting a different value using one of the five **Set Value** buttons. Select the **Clear Value** button to clear the **Value** field. As stated earlier, leaving the **Value** field empty means the dynamic label can only be updated using expressions.

Although it is not necessary, add a **Static Label** to the dynamic label definition. If this is not done, there will be no place holder for the dynamic label on the layout after the dialog is closed. This label can still be found by dragging a rubber band box in the selection mode around the area where it was placed. A very small selection box may appear at the location of the label.

The label's properties can then be edited by choosing **Edit/Properties** off the menu. Also, adding a static label to the side of the dynamic label makes it simpler to find the dynamic label location and provides a description of the value being updated. The static label is not replaced when dynamic value is updated since they are two separate labels.

Background Graphics

Select the Background Graphic icon from the palette and move it to the layout to add a background graphic. The **Select** background dialog will open. Choose the background, and select **OK** to close the dialog. Once the graphic is on the layout, it can be resized by selecting **Edit/Resize**. Note that background graphics cannot be resized using the resize handles.

The properties of the Background Graphic has two options on the properties dialog, **Locked** and **On Top**.

The **Locked** option locks the Background Graphic to its current position on the layout, preventing inadvertent moving of the Background Graphic while editing or navigating.

Turning the **On Top** option on brings the Background Graphic to the front of the layout display. Typically this option is left off, so that the Process, Activities, and Connectors on the screen will appear on top of the Background Graphic.

Importing Graphics Image Files

A Graphics Interchange Format (gif), Joint Photographic Experts Group (jpeg or jpg), or Portable Network Graphics (png) graphic can be imported into SIMPROCESS. An imported graphic can be used as a Background Graphic, as an icon representing a Process or Activity, or as an icon representing an Entity.

Importing Background Images

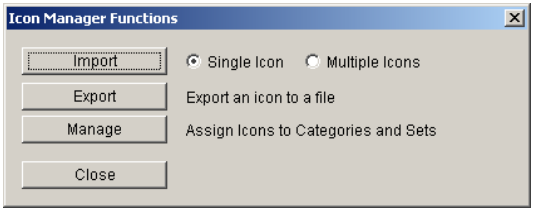
Select **Import Background** from the **File** menu to use an imported graphic as a background. This will open the **Import Background Image** dialog.

Select the **Browse** button, and choose a graphics file. Enter a name in the **Background Name** field. This is the name that will display in the list of available backgrounds. Select **OK** to import the graphics file for use in SIMPROCESS.

Importing Activity, Process, and Entity Images

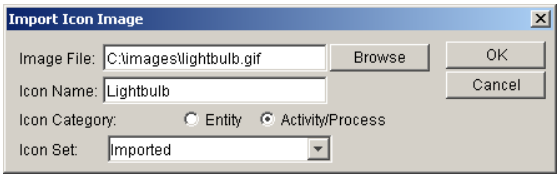
Use the Icon Manager (**Tools/Icon Manager**) to import a graphics file for use as a Process, Activity, or Entity.

The **Icon Manager** is used to import, export, and manage image files. A single image file can be imported for use as an icon, or multiple files (such as a directory of image files) can be imported.

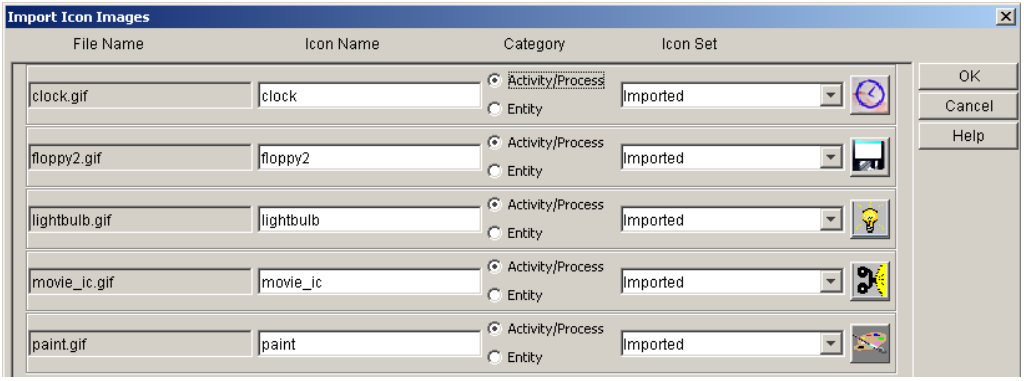


Choose **Single Icon** and click **Import** to import a single image for use as an icon. Use the **Browse** button to locate the **Image File** to import. Once selected, enter the **Icon Name** which must be

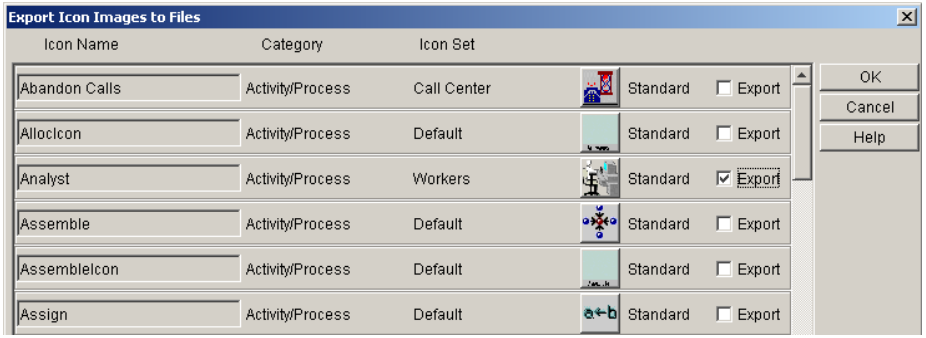
unique among all icons, no matter what category or set. Select the **Icon Category** and **Icon Set**. If the **Icon Set** needed is not listed, create a new set by typing it in the **Icon Set** field. Click **OK** to finish the import.



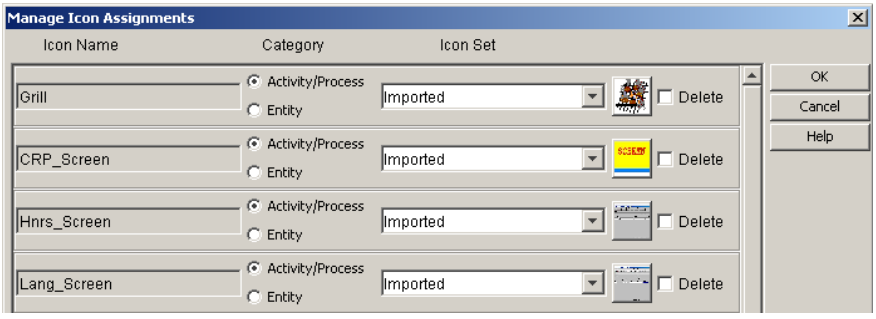
A directory of images can be imported by choosing **Multiple Icons** and clicking **Import**. Using the **Browse** button, select the directory that contains the images to import. Only directories will be listed in the file chooser. Files will not be visible. All `.gif`, `.jpg`, and `.png` files in the directory will be imported. The **Icon Name** for each will default to the name of the file minus the extension. These names can be changed as long as they remain unique among all the standard and imported icons. An error message will appear listing the names that are not unique.



Export exports images to a directory. This is useful when there are imported icons for a specific model. **Export** lists all the icons in SIMPROCESS, whether standard to SIMPROCESS or imported. The export dialog will list the **Icon Name**, **Category, Icon Set**, and whether the icon is **Standard** or **Imported**. Simply select the **Export** checkbox next to the icons to export and click **OK**. Using the **Browse** button, select the directory for the exported images.



Manage brings up a dialog that lists the imported icons. This dialog changes the **Icon Name**, **Category**, **Icon Set**, or **Deletes** the icon.



Note

When a graphic is imported into SIMPROCESS, a copy of the graphic is placed by SIMPROCESS in the `UserFiles.jar` file located in the `SIMPROCESS\SPUser` directory.

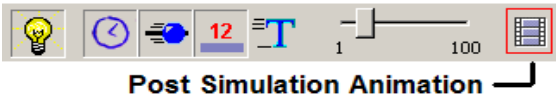
Post Simulation Animation

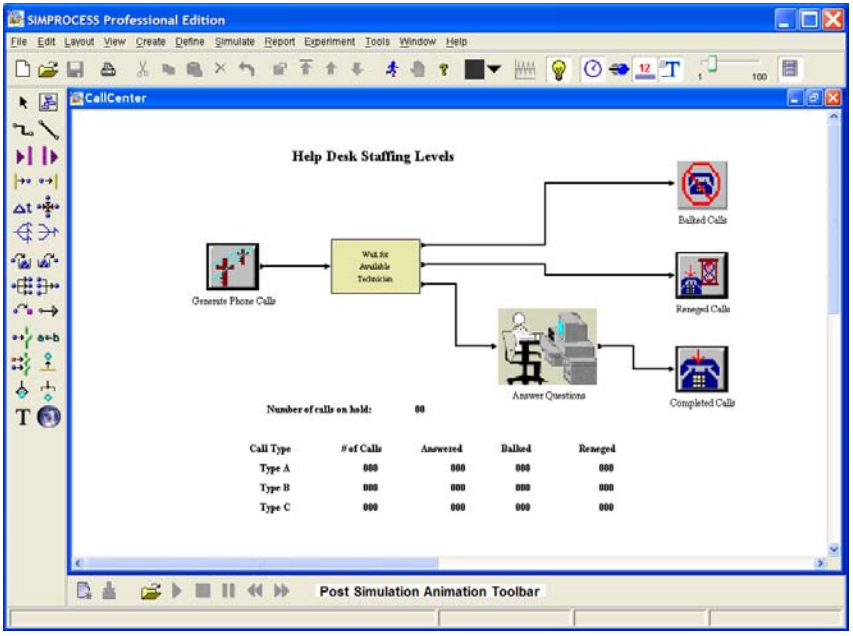
Animation is very useful in verifying and validating a model as well as communicating a model to management or customers. Normally, when turned on, animation displays while a model is simulating, which causes the simulation to slow significantly. In addition, only the animation for the current simulation time can be viewed. In other words, something in the past cannot be viewed again without restarting the simulation and waiting through the simulation to get to the point of interest.

Post simulation animation displays an animation from a simulation without the simulation running. During a simulation the animation is recorded for playback. Animations can be recorded without displaying the animation during a simulation. Playback of animations that have been recorded can be paused, fast forwarded, and rewinded.

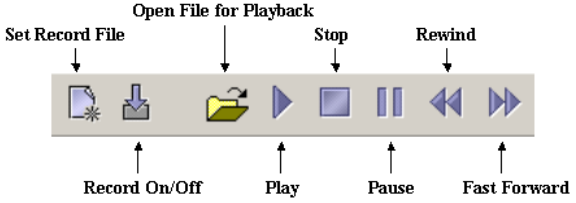
Post Simulation Animation Toolbar

Post simulation recording and playback is controlled by the post simulation animation toolbar. The post simulation animation button displays and hides the post simulation animation toolbar. The button is to the right of the **Animation Speed** slider on the main SIMPROCESS toolbar (highlighted in red below). The toolbar displays at the bottom of the SIMPROCESS layout.





The two buttons on the left are for recording, and the remainder are for playback.



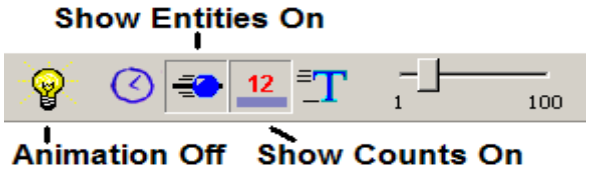
Recording an Animation

Animation events are recorded in a file for playback. In order for the **Record On/Off** button to be active, an animation event file must be set using the **Set Record File** button. The **Set Record File** button brings up a dialog where the name of the file is entered. Do not enter the path to the file. Animation event files are automatically created in the model's directory. The file name is saved with the model. If an animation event file had been previously set, the **Record On/Off** button will activate when the toolbar is displayed.

The **Record On/Off** button is a toggle button. When the button is selected, animation events

are recorded. Thus, recording can be turned on and off multiple times during a simulation.

The animation option buttons on the main toolbar, or the **Animation Settings** dialog (**Simulate/ Animation Settings** menu item) control which animation events are recorded. **Animation On**, **Show Clock**, and **Animation Speed** (slider) do not apply to recording animation events. The events recorded are determined by the status of **Show Entities**, **Show Counts**, and **Update Dynamic Labels**. If an item is selected, those type of animation events are recorded. In the example below, only the movement of entities and Activity counts would be recorded. Note that the **Animation On** button is not selected. Animation does not need to display during recording.



Warning: Animation events files can be very large. When recording counts and movement of entities, animation events for every level of the model must be recorded. Recording all that information will create very large files if recording is done for the whole simulation. The larger the model is, the larger the animation event file will be. Recording the movement of entities has the biggest impact. Recording only dynamic label events and/or Activity count events typically produces much smaller files.

Animation Playback

An animation event file of an animation that has been recorded must be opened for playback. This is done using the **Open File** button on the post simulation animation toolbar.

Important: Make sure the animation event file opened was recorded from the currently active model. The file browser will automatically open to the directory of the model. If the model has changed since the animation event file was created, delete the previous animation event files and record again.

Play

Once a file has been opened, the **Play** and **Fast Forward** buttons activate. Pressing **Play** will start the playback from the beginning of the animation event file.

Fast Forward

Pressing **Fast Forward** brings up a dialog where an amount of time to skip is entered. Note that the value entered must correspond to the **Simulation Time Units** set in the **Run Settings.** (See "Setting the Simulation Time Unit" on page 78.) That time unit will display on the dialog. If **Fast Forward** is used before **Play,** the time entered fast forwards the playback from the beginning of the simulation. Thus, if recording did not begin at the start of the simulation, it is possible that the time entered for **Fast Forward** will still be before recording began. So when **Play** is pressed, the playback begins where recording started.

Rewind

Rewind is available once playback has started. Pressing **Rewind** brings up a dialog where the amount of time to back up is entered. This time must fall within the model's **Simulation Time Units**. The playback starts over at the beginning if the time entered goes past the beginning of the playback.

Note: Both **Fast Forward** and **Rewind** have an advantage over animation during simulation. During simulation, Activity counts and dynamic labels only update when an entity enters or leaves an Activity/Process. So, when navigating through models during a run, there is normally a wait for counts and dynamic labels to display the most current values. A **Fast Forward** or **Rewind** during playback causes all counts and dynamic labels on the current level to immediately update to their values at that time.

Stop

Stop ends the playback.

Pause

When selected, the playback pauses. Press again to resume the playback.

Animation Controls

The animation buttons on the main toolbar control what is visible during a simulation animation, and they control what is visible during animation playback. Just like during simulation animation, disabling **Show Entities** will stop the display of the movement of entities. **Show Counts** and **Update Dynamic Labels** work similarly. Remember, the **Animation On** setting has no effect on animation playback. Also, these animation settings have no effect if those particular animation events were not recorded.

CHAPTER 7

Activity-Based Costing

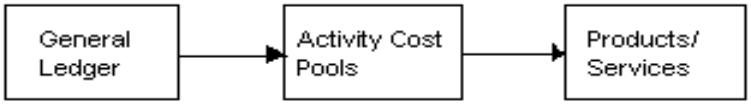
The purpose of this introduction to Activity-Based Costing (ABC) is to summarize its basic principles and describe the benefits of the integration provided with SIMPROCESS. A list of ABC references is provided in the back of the chapter for further reading.

The goal of ABC is to mimic the causal relationships among Resources, Activities, and Entities in assigning overhead costs. “The fundamental belief behind this costing approach is that cost is caused and causes of cost can be managed. The closer you can come to relating the costs to their causes, the more helpful your accounting information will be in guiding the management decisions of your business.” states the *Ernst & Young Guide to Total Cost Management* (Ernst & Young, 1992).

Enterprises use Resources to conduct activities. Resources perform activities to add value to products and services. The key to understanding cost dynamics in any enterprise is modeling the relationship between activities and their causes; and the relationship between activities and costs. If cost dynamics are not modeled (which is usually the case with traditional management accounting information systems), the performance information provided is incomplete or misleading.

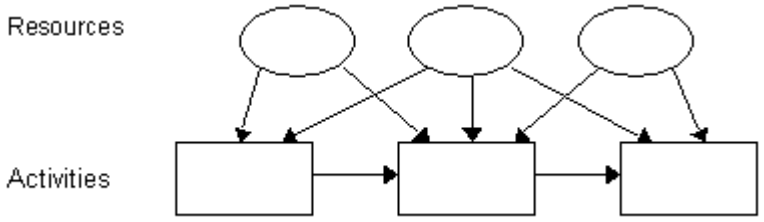
ABC and SIMPROCESS

Activity Based Costing is a technique for accumulating cost for a given cost object (i.e., product, service, customer) that represents the total and true economic Resources required or consumed by the object.



Activity Based Costing occurs in two phases. First, cost data is organized into Activity cost pools. In other words, the costs of significant activities are determined. This first phase is sometimes referred to as *Activity based Process costing.* Then, the amounts in the cost pools are assigned to products, services, or other cost objects. The second phase is referred to as *Activity based object costing.*

The architecture of SIMPROCESS provides an integrating framework for ABC. ABC embodies the concept that a business is a series of inter-related Processes, and that these Processes consist of activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an Activity basis.



One of the major challenges in successful implementation of ABC is finding the appropriate level of detail for the business Process analysis. The organization of business Processes is critical to reorganizing the cost data into Activity pools. The hierarchical modeling approach of SIMPROCESS facilitates this organization and accommodates varying levels of detail for ABC analysis. Another significant value of the ABC analysis in SIMPROCESS comes from the dynamic analysis of costs based on the event-driven simulation. Because SIMPROCESS tracks Resource interdependencies and captures the random nature of Processes, the cost statistics provided by SIMPROCESS are far more accurate than results obtained from static analysis.

Benefits of ABC with SIMPROCESS

Focus on Cost Drivers

One of the most important benefits of ABC is the focus it provides for estimating the key causes of costs. Executives can use these estimates to prioritize and monitor improvement efforts. For example, understanding the cost of poor quality can justify the investment in a quality program. Likewise, understanding the cost of complex or diverse products and services can help streamline the product and service offerings.

Strategic Pricing

Life cycles of product and services are becoming shorter and shorter. The up-front costs of developing, testing, and marketing are not recouped until revenue is generated. Understanding the cost trade-off between life cycle stages is critical to strategically pricing the products, i.e., understanding when the total investment in product development can be recouped is valuable information for strategic pricing. ABC with SIMPROCESS allows simulation of the Process changes during the life cycle of a product/ service for strategic or time-based pricing.

Evaluation of Capital Investments

Reengineering business Processes requires a trade-off between the benefits and costs of making Process improvement changes. Without the trade-off, executives and managers are faced with making large investment decisions based on gut feel.

How to Use ABC in SIMPROCESS

To get Process cost information from a SIMPROCESS model, first to define the costs of the model's Resources and the cost periods to be analyzed. SIMPROCESS will distribute these costs to activities and to Entities as the simulation proceeds and provide extensive reporting of the results based on user-specified cost reporting periods.

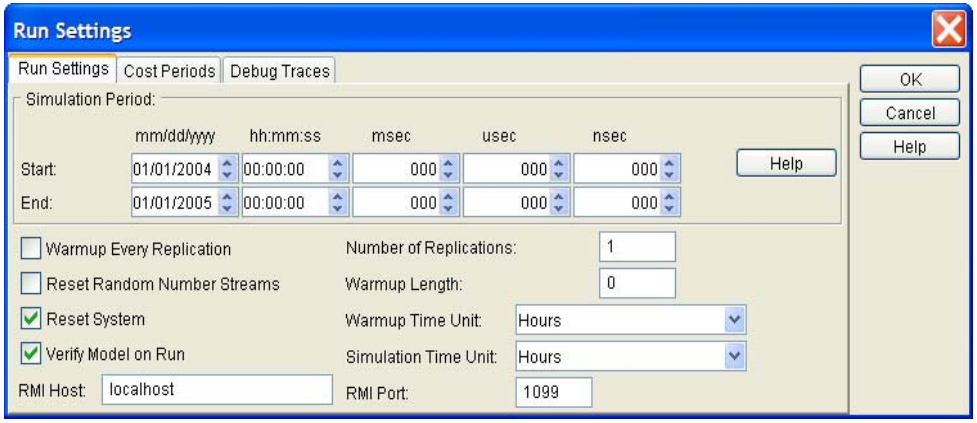
In order to provide a comprehensive cost analysis, SIMPROCESS differentiates between fixed costs and several types of variable costs that can be assigned to a Resource. SIMPROCESS allows multiple cost periods to be analyzed simultaneously and allows model level definition of costing periods. These features help to bridge the gap between an accountant's view and a manager's view of a business Process, provide an effective communication vehicle for the participants in a Process reengineering project, and make SIMPROCESS a complete business Process analysis tool.

SIMPROCESS' costing facility is very simple to use. Prior to running a simulation, define the cost periods for cost calculation purposes or accept the default cost periods, which are based on calendar weeks. Also, define costs for at least some of the Resources in the model, presumably those that represent the most significant costs in the business Process (hourly payroll, salaries, capital equipment depreciation, etc.). The following describes how to complete these two steps.

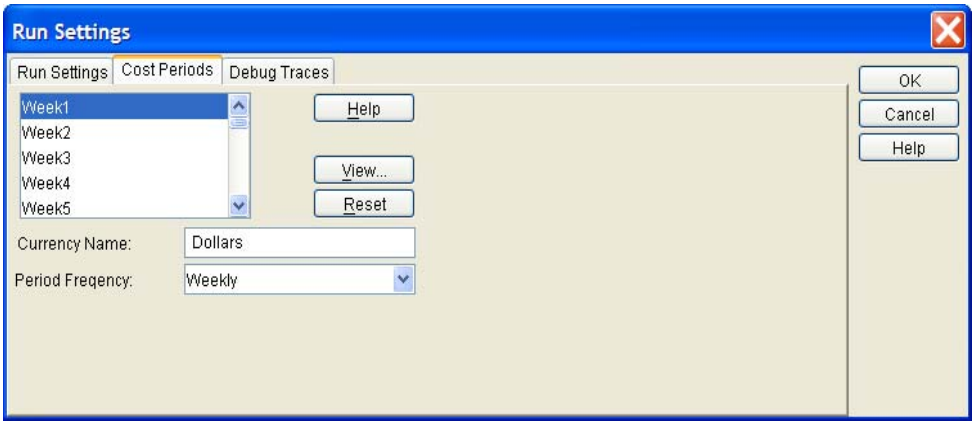
Setting Up Cost Periods

Pick the cost periods that are most suitable for the system under study. SIMPROCESS selects weekly cost periods as the default but allows monthly, quarterly, half yearly, and yearly cost periods. The following example demonstrates how to set cost periods for the calendar year 2004.

Select **Simulation/Run Settings** from the main menu.



Then, click on the **Cost Periods** tab. This will display the **Cost Periods** definition tab as shown below.



The list in the upper left of this dialog shows the currently defined cost periods. The default periods are Week1, Week2,..., Week53. At the bottom of the dialog, is the **Period Frequency** selection list with the default *Weekly* selected. Click the down arrow button to see all of the **Period Frequencies** that SIMPROCESS offers: **Weekly**, **Monthly**, **Quarterly**, **Half Yearly**, and **Yearly**. Notice that if a new **Period Frequency** is selected, SIMPROCESS will create a new set of periods in the period list and assign each a default name (Month1, Month2,..., or Quarter1, Quarter2,...). Notice also that SIMPROCESS will automatically create and name enough cost periods to span the currently specified run length. (The simulation **Start Time** and **End Time** are set from the **Run Settings** tab.)

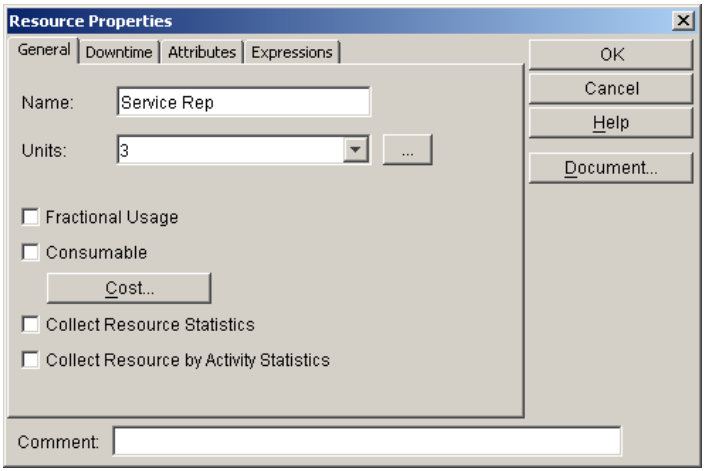
This dialog also sets the name of the **Currency** used on the cost reports. This is a simple label used in the reports. SIMPROCESS provides no currency conversion facilities and assumes that all cost amounts are in the same currency (e.g., Dollars or Euros).

When a particular cost period is selected and the **View...** button is clicked, SIMPROCESS will display the **Cost Period** detail dialog which shows the start and end dates and times for the cost period and the name of the period. The name of each cost period can be changed to be more descriptive in the context of the cost report. For example, the cost periods could be called Spring, Summer, Fall, and Winter rather than Quarter1, Quarter2, etc. Click the **OK** button to alter the cost period name or the **Cancel** button to discard any changes.

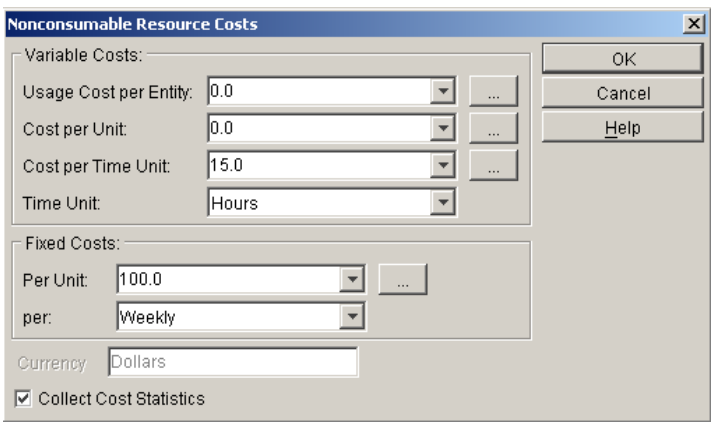
Setting Up Resource Costs

Costs can be specified for each Resource in the model. All Resources do not have to have costs specified. SIMPROCESS will generate cost reports only for those Resources that have costs assigned. Both fixed and variable costs can be assigned to non-consumable Resources, and variable costs can be assigned to consumable Resources. These costs are specified as part of defining each Resource.

Select the **Define/Resource** option from the menu bar. Then pick a previously defined Resource from the list for editing or add a new one using the **Edit** or **Add** buttons. This will display the **Resource Properties** dialog as shown below:



Click the **Cost...** button to display the **Resource Costs** dialog for this Resource. It looks like the following:



The box at the top of this dialog shows the **Variable Costs,** and the box below shows the **Fixed Costs**.

The check box at the bottom left-hand corner of the dialog, **Collect Cost Statistics**, is turned on by default whenever cost information is entered. Leave this selected. Otherwise, cost statistics will not be gathered.

Variable Cost

Three types of variable costs can be specified for non-consumable Resources:

- Usage Cost per Entity - This cost is applied to each Entity that is Processed by the Resource. It is used to represent “flat fee” charging schemes. The same cost is assigned regardless of the amount of the Resource's units that is used or the duration of the Activity. Example: Often administrative charges or service call charges are based on this kind of charging scheme.
- Cost Per Unit - This cost is applied to each Entity that is Processed based only on the amount of the Resource's capacity that is used to Process the Entity. The cost is not calculated based on the time that the Activity takes to complete. Example: Fuel may be defined as a consumable Resource and cost per unit may be $1.50 per gallon. Every time a gallon of fuel is consumed, it will cost $1.50.
- Cost per Time Unit - This cost is calculated based on the amount of Resource capacity used and the time used. Example: Machine rental charges or hourly salary paid to employees are a common example of this type of cost.

Time Unit

Time unit that applies to the **Cost per Time Unit**. Defaults to **Hours**.

Fixed Costs

Fixed Costs are defined in the box below the **Variable Costs** box. Enter the fixed cost amount in the **Per Unit** value box, and select the time basis for the cost from the selection list below. Machine depreciation or fixed salaries are common examples of this type of cost. To specify the fully burdened cost of a set of salaried employees represented by this Resource, and the cost per employee is $50,000 per year, enter 50000 in the **Per Unit** box, and select **Yearly** from the list below. Click the down arrow to the right of the list to see the available items. The list contains the same time intervals that are available for the **Cost Period Frequency**. These do not have to be the same in both places. SIMPROCESS will perform all the necessary conversions automatically.

For example, annual salaries can be specified and the simulation run with weekly cost periods. SIMPROCESS will convert the annual salary costs to weekly costs when generating the cost data. After a simulation is completed, reports of the costs are available. The total cost and the cost by period can be seen by choosing **Display Standard Report** from the **Reports** menu. These costs are divided into three categories: **Resource by Activity**, **Resource by Entity**, and **Activity by Entity**.

Cost Calculations

When a simulation is run, SIMPROCESS pauses at the end of each cost period to calculate the period costs. SIMPROCESS tracks all the activities that used the Resource and all of the types of Entities

processed. For each Resource that has specified costs and that is set to calculate costs, SIMPROCESS will distribute the Resource's fixed and variable costs for the period to all of the activities that made use of the Resource during the period. This distribution is based on the amount of the available capacity used by the Activity during the period. For example, suppose that a Resource is used evenly by two activities and was busy 50% of the time for the cost period. Further, suppose that during the period each Activity processed five Entities, two of type A and three of type B. SIMPROCESS will calculate the costs for this period as follows:

1. Calculate the variable costs for each Resource based on the number of Entities Processed and the processing times as described.
2. For each of the two Resources, calculate the portion of fixed cost represented by idle time. Then calculate both the fully absorbed and capacity-based fixed costs. (In this case, the fully absorbed costs should be twice the capacity costs, since the Resource was 50% idle during the period.)
3. Add the variable costs to the fully absorbed costs and the capacity-based costs, creating two period costs for each Resource.
4. Divide the period costs for the Resource based on the usage by activities. (In this case, the period costs will be split evenly between the two activities.)

These steps are completed for all Resources in the model that are set to calculate costs. Each Activity accumulates its period costs from all of the Resources that it actually made use of during the period. Next, SIMPROCESS will calculate the Entity costs based on these Activity costs. After all Resource costs are distributed to the activities, the Activity costs are then distributed to each type of Entity Processed by the Activity, based on the total number of Entities Processed. These calculations proceed as follows:

1. The Activity determines the total number of Entities Processed for the period and the portion of this total represented by each type.
2. The Activity costs are apportioned to the Entities based on the number of each Entity type divided by the total number of Entities.

The pool of Activity cost is broken out to each Entity type based on the Entity usage of that Activity. The Activity cost is displayed in the cost report for the total number of each Entity type, not for each Entity instance. To calculate the Entity instance cost, divide the cost for that Entity type (the cost number displayed in the report) by the total number of Entities of that type processed (available in the Standard Report).

Upon completion of these calculations, SIMPROCESS resumes the simulation for the next cost period.

Note

> Get Resource Activities accumulate the costs of Resources obtained at Get Resource Activities. This is because the Resource was not actually assigned to any of the activities where processing occurred.

References

Michael R. Ostrenga, Terrence Ozan, Robert Mc Ilhattan, Marcus Harwood, *The Ernst & Young Guide to Total Cost Management*, John Wiley & Sons, New York, 1992.

Douglas Webster, *Activity Based Costing: A Tool for Reengineering the Enterprise*, Enterprise Reengineering, April/May 1995, pp. 18-23.

CHAPTER 8

Output Reports

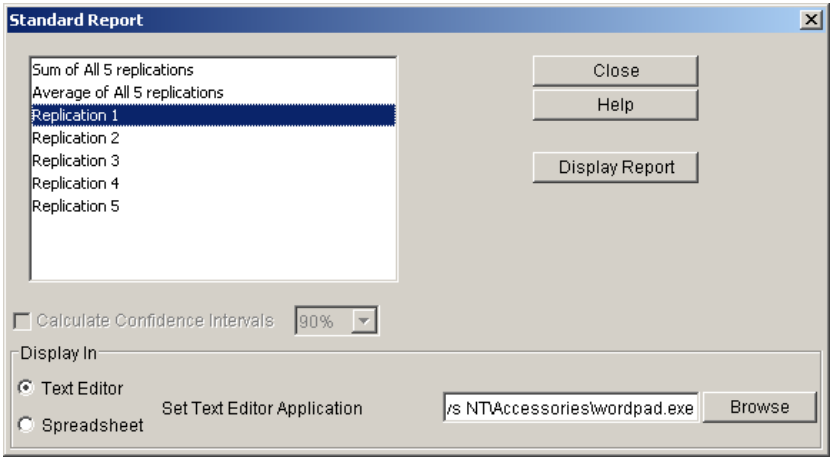
SIMPROCESS collect statistics by default for all Entities and all Resources for the Standard Report. SIMPROCESS also allows the definition of custom statistics to gather more specific information about a model. The Entity and Resource statistics gathered for the Standard Report will usually be sufficient when starting a model. As the focus of the analysis is sharpened and the model becomes detailed, custom statistics will be added to narrow in on the performance measures of most interest.

Further, real-time plots (see "Real-Time Plots," beginning on page 176) and SIMPROCESS dashboards (see Chapter 16, "SIMPROCESS Dashboards," beginning on page 379) can be viewed, a Simulation Results file containing all the statistics gathered from the model can be exported in a tab-delimited format (see "Simulation Results File," beginning on page 504), and results can be exported to a database (see Chapter 13, "SIMPROCESS Database," beginning on page 322).

Standard Report

After the simulation run has completed, display the Standard Report to view output statistics for the model. From the **Report** menu bar, choose **Display Standard Report**.

This will open the **Display Standard Report** dialog. In the **Report Replications** list box (if the model ran for multiple replications), an individual **Replication**, the **Average of All Replications** run, or the **Sum of All Replications** run can be selected. Typically, for runs of multiple replications the **Average of All Replications** report is most useful. **Calculate Confidence Intervals** is activated if the **Average of All Replications** report is selected. **Calculate Confidence Intervals** allows selection of 90%, 95%, or 99% confidence intervals for each performance measure. Next, select to view the Standard Report with a **Text Editor** (Wordpad by default on Windows) or with a **Spreadsheet**. Press the **Display Report** button to open the report.



To view the Standard Report with a spreadsheet, select **Spreadsheet**, then use the **Browse** button to point to its executable, i.e., `Excel.exe`. Once the spreadsheet is open, the Standard Report data is best viewed in the left justified mode and with **AutoFit** checked for the columns.

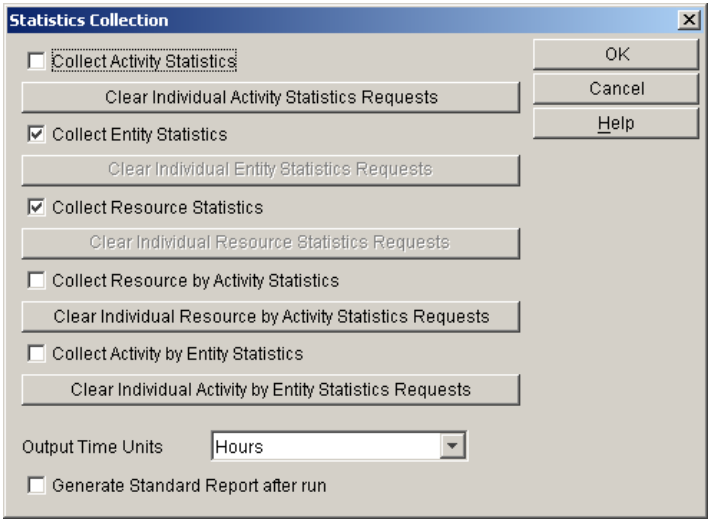
Default Performance Measures

SIMPROCESS will collect by default the following performance on Entities and Resources:

- For each Entity defined in the model, Cycle Time and Count statistics are displayed.
- For each Resource defined in the model, average and maximum number of units busy is measured and shown as a percent of capacity.

- ABC reports for each Resource with cost defined in the model. The ABC reports have three sections that are broken down by cost period and total cost. These sections are **Resource by Entity**, **Resource by Activity**, and **Activity by Entity**. See Chapter 7–Activity-Based Costing, beginning on page 153 for more detail on Activity-Based Costing.

On the **Report** menu, **Define Global Statistics Collection** brings up a dialog that sets global statistics options. As stated above, **Collect Entity Statistics** and **Collect Resource Statistics** are selected. The results of the selection options are described in the following sections. The **Output Time Units** field sets the units for cycle time statistics in the Standard Report. **Generate Standard Report after run** causes the Standard Report to be generated automatically after a simulation run. This is most useful when using the Experiment Manager (page 334) or optimization (page 349). Note that Standard Reports generated automatically are not accessible from within SIMPROCESS. The file (which is located in the model's directory) must be opened separately.



Attributes are handled differently for the Standard Report. The **Standard Report** check box on the **Attribute Properties** dialog must be selected for each attribute that needs to collect statistics. The report will display either Time-weighted or Observation-based statistics depending on the option chosen. Statistics can be kept for all types of attributes except Entity Instance Attributes. Lastly, if the value of an attribute does not change during the simulation run, its statistics will all be zeroes in the Standard Report. See "User Defined Attributes," beginning on page 215 for more information on Attributes.

Custom Statistics

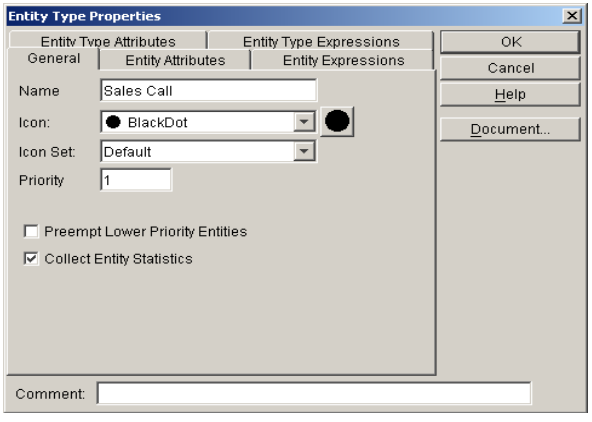
SIMPROCESS provides the ability to add custom statistics to the Standard Report for analyzing the performance of business Processes. Such performance measures as cycle time, Activity costs, and Resource utilization can be calculated by SIMPROCESS. This chapter describes the types of statistics available, and how to define, display, print, and export them.

Entity Statistics

Entity statistics provide detailed information about the numbers of Entities existing in the model during a simulation and the amount of simulation time (cycle time) that Entities require to pass through the model. SIMPROCESS provides five types of Entity statistical reports:

- Total Count
- Real-time Plots
- Entity Count by State
- Entity Cycle Time by State
- Attribute Value

Total Count, Entity Count by State, and Entity Cycle Time by State are selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Entity Statistics** or by choosing **Collect Entity Statistics** when each Entity is defined. If **Collect Entity Statistics** on the **Define Global Statistics Collection** dialog is selected, then the above statistics (other than Real-time Plots and Attribute Value) will be in the Standard Report for every Entity defined. If only statistics for selected Entities are desired, then the global **Collect Entity Statistics** should not be selected, and the **Collect Entity Statistics** on the Entity Definition dialog should be selected for the desired Entities.



Total Count Statistics

These statistics show the total number of Entities that have been generated during the simulation, how many remain in the system at the end of the simulation, and how many have exited the system throughout the simulation. Total Count will not be collected unless **Collect Entity Statistics** (either global or individual) is selected prior to running the simulation. The results are not available until the simulation is complete.

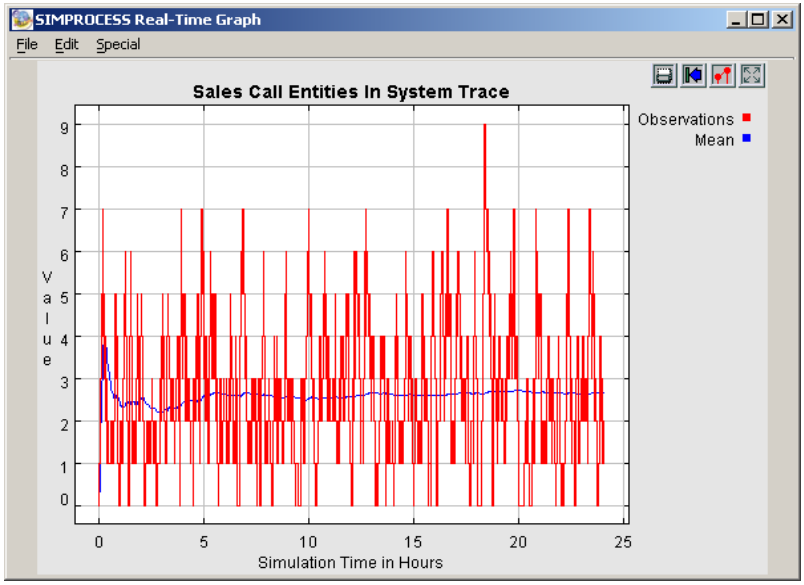
Real-time Plots

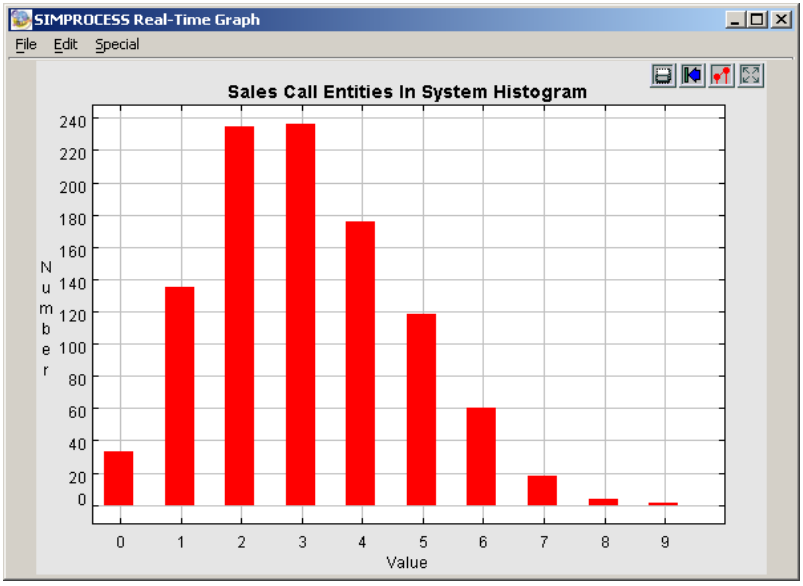
If selected, real-time plots display statistics while the simulation is running. This may slow the simulation but real-time plots give a running view of the performance metrics during the simulation. If multiple real-time plots are selected, they will be stacked on top of each other. Real-time plots can be minimized, moved, resized, or closed while the simulation is running. Real-time plots that have been closed can be displayed again. See “Displaying Real-Time Plots” on page 179.

There are two types of real-time plots: traces and histograms. Traces display the instantaneous value of a particular statistic along with a running mean. Histograms display the number of occurrences of values of a statistic. These are grouped into value ranges called bins. The bin size is set automatically by SIMPROCESS. Traces and histograms for the same statistic do not have to be displayed together. Individual charts may be selected. Real-time plots are selected under the **Report** menu item **Define Real-Time Plots/Entities**. Plots may be customized and hidden. See “Real-Time Plots” on page 176.

Cycle Times Trace and **Cycle Times Histogram** — These reports show the individual cycle time measurements for each Entity of a given type. Charts are generated for each Entity type that is selected. The charts are updated as each Entity of the given type completes its cycle time. This occurs when the Entity is transformed or disposed in the model. The observation points on the trace are connected only to improve their visibility and are not meant to suggest continuity.

Entities in System Trace and **Entities in System Histogram** — These charts show the individual Entity count measurements (that is, the number of Entities that exist in the model) for each Entity type. Charts are generated for each Entity type that is selected. The charts are updated as each Entity of the given type is created and disposed in the model.




SIMPROCESS Real-Time Graph
File Edit Special
Sales Call Entities In System Histogram
Number
Value
0 20 40 60 80 100 120 140 160 180 200 220 240
0 1 2 3 4 5 6 7 8 9

Wait For Resource Trace and **Wait For Resource Histogram** — These charts show the current number of Entities that are in the waiting for Resource state.

Wait For Resource Cycle Times Trace and **Wait For Resource Cycle Times Histogram** — These charts show the time spent waiting for Resources.

Hold For Condition Trace and **Hold For Condition Histogram** — These charts show the current number of Entities that are in the holding for condition state that may be associated with Activities such as assemble, gate, and batch.

Hold For Condition Cycle Times Trace and **Hold For Condition Cycle Times Histogram** — These charts show the time spent holding for a condition to be met.

Entities In Process Trace and **Entities In Process Histogram** — These charts show the current number of Entities that are in the Process.

Process Cycle Times Trace and **Process Cycle Times Histogram** — These charts show the time Entities spend processing.

Entity Count by State Statistics

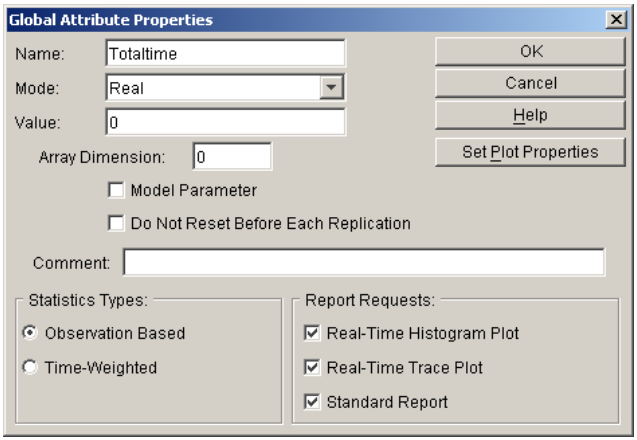
These statistics present the simulation-generated Entity count statistics for selected Entity types. Statistics are time-weighted for Entity counts. These statistics show the average number of Entities in the system broken down by three states: waiting for Resource, holding for condition, and in-process. Entity Count will not be collected unless **Collect Entity Statistics** (either global or individual) is selected prior to running the simulation. The results are not available until the simulation is complete.

Cycle Time by State Statistics

Cycle Time statistics present the simulation-generated cycle time statistics for selected Entity types. The cycle time calculations are based on the number of Entities that were processed at the end of the simulation. These statistics show the breakdown of the Cycle Time by state. The three states that an Entity may be in are waiting for Resource, holding for condition, and in-Process. Cycle Time will not be collected unless **Collect Entity Statistics** (either global or individual) is selected prior to running the simulation. The results are not available until the simulation is complete.

Attribute Value Statistics

The attribute value statistics must be specified in the dialogs where attributes themselves are defined. If the attributes are defined while Entity types are being defined, then the statistics must be selected where those attributes are defined.



Time-Weighted Average — This collects time-weighted statistics for Entity attributes.

Observation-Based Average — This collects observation-based statistics for Entity attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute's values.

Real-Time Trace Plot — This displays a trace of the attribute's values.

Standard Report — Displays the results in the Standard Report.

Set Plot Properties — Displays a plot properties dialog for each type of plot selected.

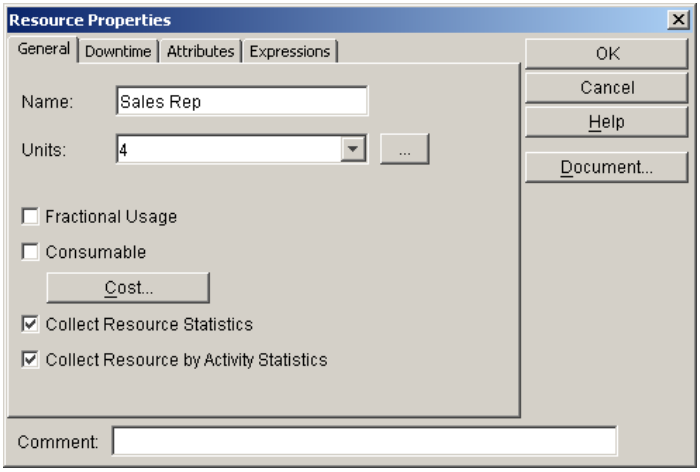
Resource Statistics

Resource statistics provide detailed information about the amount of time Resources spend in possible states during a simulation. SIMPROCESS provides four types of statistics which show various summaries of the state information for a Resource:

- Utilization by State Statistics
- Utilization by Activity Statistics
- Real-time Plots
- Attribute Value Statistics

Utilization by State is selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Resource Statistics** or by choosing **Collect Resource Statistics** when each Resource is defined. The Utilization by State statistics will be in the Standard Report for every Resource defined if **Collect**

Resource Statistics on the **Define Global Statistics Collection** dialog is selected. The global **Collect Resource Statistics** should not be selected, and the **Collect Resource Statistics** on the Resource Definition dialog should be selected if only statistics for selected Resources are desired. Similarly, Utilization by Activity is selected either from the **Define Global Statistics Collection** dialog by choosing **Collect Resource by Activity Statistics** or by choosing **Collect Resource by Activity Statistics** when each Resource is defined.



Utilization by State Statistics

These statistics present summaries of the simulation-generated statistics for the time that the number of units of the selected Resources spent in each state. The average number of units and percentages that were idle, busy, planned downtime, unplanned downtime, and reserved are shown in the Standard Report. Also included in the Standard Report are the percentages that a Resource was idle, busy, or reserved, given the Resource was available. That is, downtime (planned or unplanned) is not included. The time available is considered to be the total time for the Resource. Thus, if a Resource has no downtime defined, then the percentages for idle, busy, and reserved will be the same for the calculations including downtime and the calculations not including downtime.

Utilization by Activity Statistics

These statistics show the average number of units that were busy by Activity.

Real-time Plots

These reports display the simulation-generated instantaneous capacity allocations for each of the five Resource states. The reports present their data while the simulation is running. This may slow the simulation but they provide a running view of the Resource's behavior throughout the simulation. Real-

time plots are selected under the **Report** menu item **Define Real-Time Plots/Resources**.

All report data is shown on an X-Y plot where the (horizontal) X-Axis represents simulation time and the (vertical) Y-Axis shows the Resource's units. One chart is produced for each selected Resource. Plots may be customized and hidden. See “Real-Time Plots” on page 176.

Capacity Trace and **Capacity Histogram** —These reports show the capacity of a Resource during the simulation. These reports are only useful for consumable Resources.

Units Idle Trace and **Units Idle Histogram** —These reports show the amount of a Resource's units which are left idle during the simulation.

Units Busy Trace and **Units Busy Histogram** —These reports show the amount of a Resource's units which are busy during the simulation.

Planned Downtime Trace and **Planned Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to planned downtime during the simulation.

Unplanned Downtime Trace and **Unplanned Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to unplanned downtime during the simulation.

Total Downtime Trace and **Total Downtime Histogram** —These reports show the amount of a Resource's units which are not available due to unplanned and planned downtime during the simulation.

Units Reserved Trace and **Units Reserved Histogram**—These reports show the amount of a Resource's units which are in reserved state during the simulation.

Attribute Value Statistics

The attribute value statistics must be specified in the dialogs where attributes themselves are defined. If the attributes are defined while Resources are being defined, then the statistics must be selected where those attributes are defined.

Time-Weighted Average — This collects time-weighted statistics for Resource attributes.

Observation-Based Average — This collects observation-based statistics for Resource attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute’s values.

Real-Time Trace Plot — This displays a trace of the attribute’s values.

Standard Report — Displays the results in the Standard Report.

Process/Activity Statistics

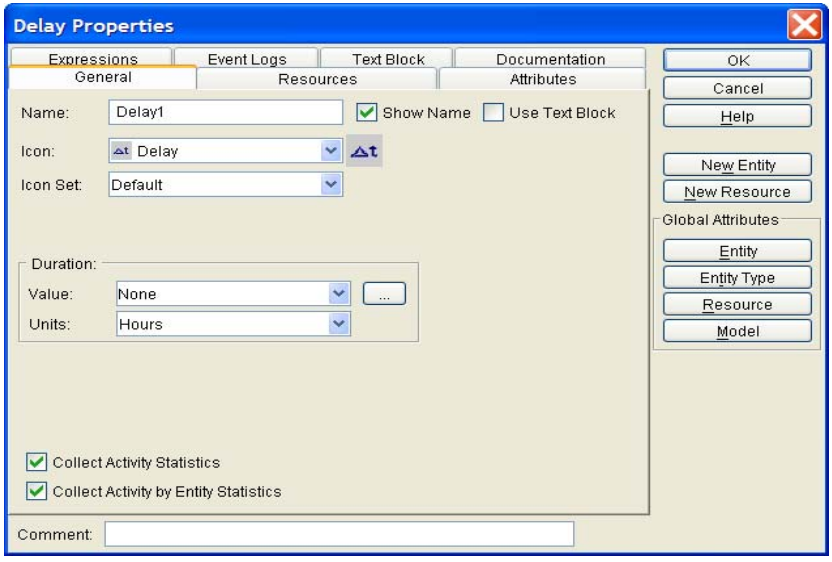
Process/Activity Statistics provide detailed information about the numbers of Entities entering and leaving particular Processes/Activities during a simulation. SIMPROCESS provides seven types of Activity statistics:

- Cycle Time by State
- Real-time Plots
- Total Entity Counts
- Entity Count by State
- Cycle Time by State by Entity
- Entity Count by State by Entity
- Attribute Values

The Process/Activity statistics are limited in scope to specific Processes/Activities in contrast to Entity statistics which encompass the entire model. Cycle Time by State, Total Entity Counts, and Entity Count by State are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Activity Statistics** or locally by choosing **Collect Activity Statistics** on the individual Activity properties dialog. Activity statistics will be in the Standard Report for every Activity defined if **Collect Activity Statistics** on the **Define Global Statistics Collection** dialog is selected. The global **Collect Activity Statistics** should not be selected, and the local **Collect Activity Statistics** on the Activity properties dialog should be selected if only statistics for selected Activities are desired. Similarly, Cycle Time by State by Entity and Entity Count by State by Entity are selected globally from the **Define Global Statistics Collection** dialog by choosing **Collect Activity by Entity Statistics** or locally by choosing **Collect Activity by Entity Statistics** on the appropriate Activity.

WARNING

Collect Activity Statistics and **Collect Activity by Entity Statistics** should NOT be selected from the Global Statistics Collection dialog for large models. This could cause memory problems and would lead to much unneeded information. It is recommended that Activity statistics always be selected at the appropriate Activity.



Cycle Time by State Statistics

These statistics present the simulation-generated cycle time statistics for the selected Process/Activity and are calculated based on the Entity counts for the selected Processes/Activities.

Cycle Time statistics present the simulation-generated cycle time statistics for Entity types that processed at the selected Activities or Processes. The cycle time calculations are based on the number of Entities that were processed at the end of the simulation. These statistics show the breakdown of the Cycle Time by state. The three states that an Entity may be in are waiting for Resource, holding for condition, and in-Process. Cycle Time will not be broken down by state for Processes. Cycle Time will not be collected unless **Collect Activity Statistics** (either global or individual) is selected prior to running the simulation. The results are not available until the simulation is complete.

Real-time Plots

Real-time Plots display statistics while the simulation is running. This may slow the simulation but shows a running view of the Entity count throughout the simulation. The selected charts are generated for each Process/Activity selected. The observation points are connected in trace charts to improve their visibility and are not meant to suggest continuity. The charts are updated as an Entity leaves the Process/Activity. Plots may be customized and hidden. See “Real-Time Plots” on page 176.

Cycle Times Trace and **Cycle Times Histogram** —These charts show the individual cycle time measurements for each Process/Activity.

Wait For Resource Cycle Times Trace and **Wait For Resource Cycle Times Histogram** —These charts show

the individual wait for Resource time measurements for each Activity. These charts are not available for Processes.

Hold For Condition Cycle Times Trace and **Hold For Condition Cycle Times Histogram**—These charts show the hold for condition time measurements for each Activity. These charts are not available for Processes.

Process Cycle Times Trace and **Process Cycle Times Histogram**—This chart shows the processing time measurements for each Activity. These charts are not available for Processes.

Entity Counts Trace and **Entity Counts Histogram**—These charts show the number of Entities in each Process/Activity.

Wait For Resource Trace and **Wait For Resource Histogram**—These charts show the number of Entities waiting for Resources for each Activity. These charts are not available for Processes.

Hold For Condition Trace and **Hold For Condition Histogram**—These charts show the number of Entities holding for a condition for each Activity. These charts are not available for Processes.

Entities In Process Trace and **Entities In Process Histogram**—These charts show the number of Entities processing for each Activity.

Entity Count Reports

These reports present the simulation-generated Entity count statistics for selected Processes/Activities. Entity Count will not be collected unless **Collect Activity Statistics** (either global or individual) is selected prior to running the simulation. Count by Entity Type will not be collected unless **Collect Activity by Entity Statistics** (either global or individual) is selected prior to running the simulation. The results are not available until the simulation is complete.

Total Entity Count—This report shows the total number of Entities that (1) have arrived at the Process/Activity, (2) are remaining in the Process/Activity at the end of the simulation, and (3) have been processed by the Process/Activity.

Count By Entity Type—This report shows the average and maximum Entity counts broken down by Entity states, that were processed by the selected Activity. That is, how many were in the Activity, Wait For Resource, In Process, and Hold for Condition states. Entity counts for Processes will not be broken down by state.

Attribute Value Reports

The attribute value reports must be specified in the dialogs where the attributes themselves are defined. If the attributes are defined locally for a Process/Activity, then the reports must be selected where those attributes are defined.

Time Weighted Average—This collects time-weighted statistics for the selected Process/Activity attributes.

Observation Based Average — This collects observation-based statistics for the selected Process/ Activity attributes.

Real-Time Histogram Plot — This displays a histogram of the attribute's values.

Real-Time Trace Plot — This displays a trace of the attribute's values.

Standard Report — Displays the results in the Standard Report.

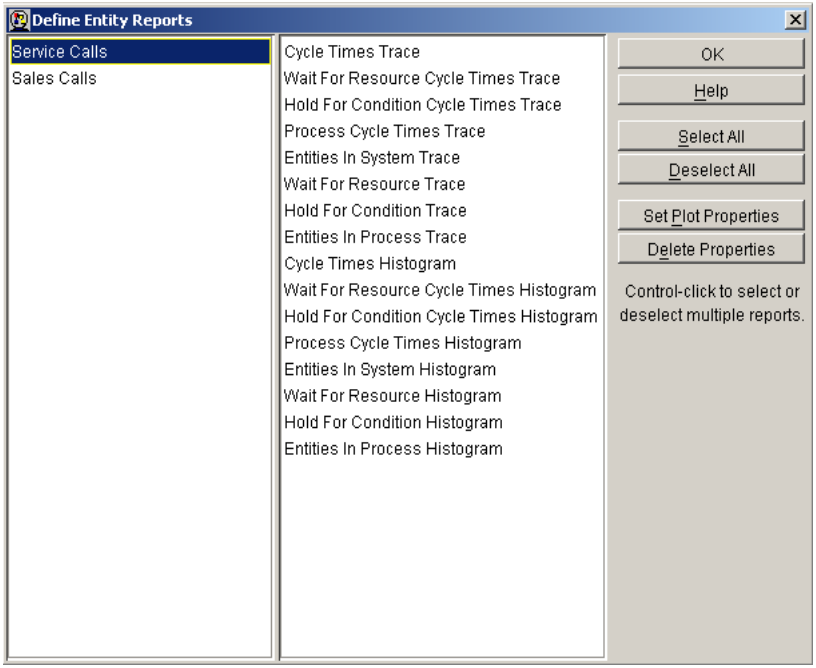
Real-Time Plots

Real-Time Plots display the change in value of statistics as the simulation runs for Entities, Resources, Activities, Processes, Time Stamps, and Attributes.

Defining Plots

Entities, Resources, and Activities

Plots for Entities, Resources, Activities, and Processes are defined on the **Report** menu.



Selecting **Entities...**, **Resources...**, or **Activities...** from the **Define** menu will bring a dialog listing the appropriate type of items defined in the model on the left, and the real-time plots available for that item on the right. Select an item on the left, then select the plots desired on the right. Multiple items can be selected on the right by holding down the Control key when selecting. The **Select All** button can be used if all plots are desired. The **Deselect All** button deselects all plots.

Once the desired plots have been selected, click **OK**. During the simulation, when the first value occurs for a particular plot, the plot appears. The plot will remain unless minimized or closed. Real-time plots

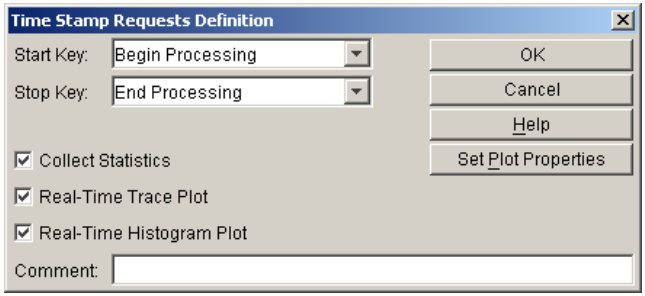
that have been closed can be displayed again.

NOTE

> Real-Time plots that have been displayed will not automatically disappear at the end of a simulation run. Each one must be closed individually. Note that all open plots will be closed when SIMPROCESS is closed.

Time Stamps

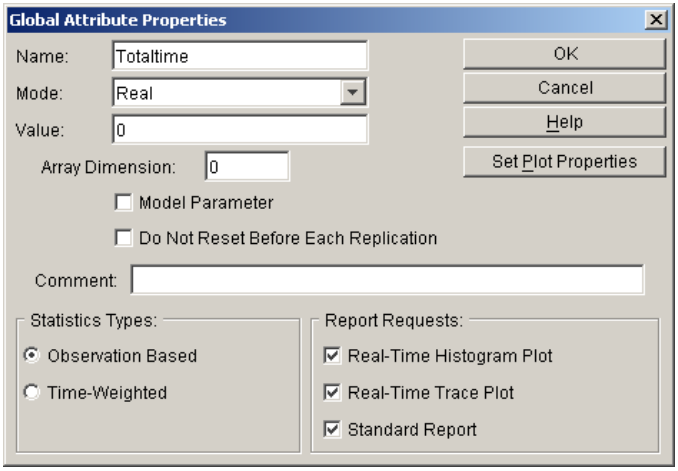
Plots for time stamps are determined when the time stamp is defined. Select **Time Stamps...** from the **Define** menu, and choose **Add** for a new time stamp or **Edit** to add plots to an existing time stamp. Enter or edit the **Start Key** and **Stop Key**.



Select **Collect Statistics** to report the statistics on the Time Stamp in the Standard Report. **Real-Time Trace Plot** causes the creation of trace plot of the data, and **Real-Time Histogram Plot** causes the creation of a histogram of the data.

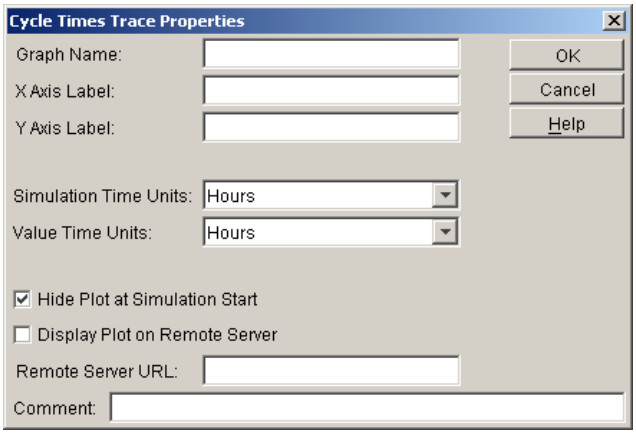
Attributes

Attribute plots are selected on the attribute definition dialog. All attribute types except Entity Instance attributes can have plots. Trace or histogram or both can be selected. Plots will be created for each item defined in the model if the attribute is a global Entity, global Resource, or global Activity attribute. For instance, if there are ten Activities/Processes in a model, and a global Activity attribute is defined with plots, then 10 sets of plots will be created since each Activity will have the attribute. Except for Model attributes, it is best to use local attributes when selecting plots for an attribute. Also, if an attribute is an array attribute, plots will be created for each member of the array.



Setting Plot Properties

Each item that can have plots has a **Set Plot Properties** button. This button sets the plot title, sets the X axis legend, sets the Y axis legend, hides the plot at the start of the simulation, and, depending on plot type, sets the units for the X axis and Y axis. If the plot properties are not set, defaults will apply to the plots. The default title is the item name plus the plot name. For instance, the default title for a trace of cycle times for an Activity named Delay1 would be "Delay1 Cycle Times Trace." The default units for the X axis of trace plots is the **Simulation Time Unit** selected in the Run Settings. See "Setting the Simulation Time Unit" on page 78. The default units for the Y axis of trace plots depends on the type of value being plotted. If the value is a cycle time (total, processing, wait for Resource, or hold for condition), the default unit is the **Output Time Units** selected in the **Define Global Statistics Collection** dialog. If the value is not a cycle time, then the Y axis is set according to the values plotted. Histograms follow the same rules for the X axis since the X axis plots the values in a histogram. To change any of the defaults, or to hide the plot, choose the **Set Plot Properties** button. This button will display a dialog for each plot selected.



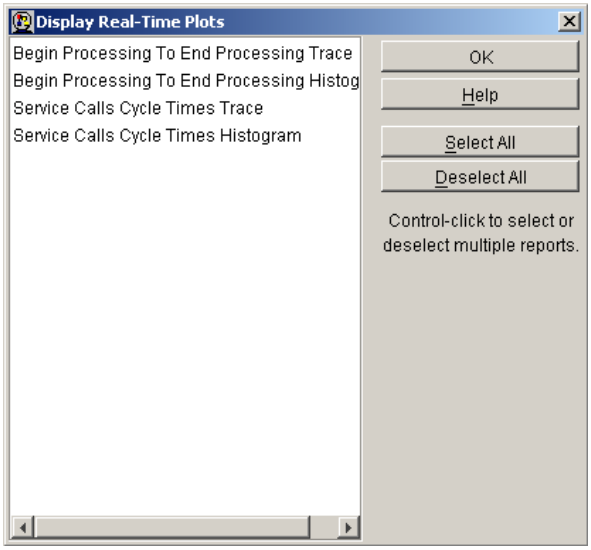
Defaults will apply if **Graph Name**, **X axis Label**, or **Y axis Label** are left blank. The properties default to hide the plot and to not display the plot on a remote server. The plot properties dialog will display **Simulation Time Units** and **Value Time Units** based on the plot type and the value being plotted. Traces of cycle times will offer both options. All other traces will only offer the **Simulation Time Units** option. Histograms of cycle times will offer the **Value Time Units** option. All other histograms will not have either option.

When plots are deselected, any properties set are lost. The properties must be reset if the plot is selected again. Also, on the **Define Real-Time Plots** dialogs for Entities, Resources, and Activities, there is a **Delete Properties** button. This button will remove the plot properties from selected plots without deselecting the plots.

Displaying Real-Time Plots

Plots that are hidden are displayed during or after a simulation by choosing **Display Real-Time Plots** on the **Report** menu or clicking the button on the tool bar. These only become active at the beginning of a simulation run.

A dialog appears that lists all plots (hidden or not) defined in the model. All the plots are listed in the same dialog regardless of type (Entity, Resource, etc.).



The plots that are selected will display when **OK** is pressed. Once a plot is displayed it can be minimized or closed. Any plot closed can be viewed again by using **Display Real-Time Plots** from the **Report** menu or the tool bar. All plots remain available for display until the model is closed. The plots are recreated if the model is run again.

Displaying Plots Remotely

The ability to display real-time plots on a remote server is a plug-in capability that can be licensed separately from CACI. The **Display Plot on Remote Server** option must be selected, and the **Remote Server URL** must be entered.

Before the model with the remote plots starts simulation, the Java RMI Registry must be started and SPPlotServer must be started on the server where the remote plots are to appear. This requires the use of the `SPRemote.jar` and `plot.jar` files which are found in the `SPSYSTEM` directory where SIMPROCESS was installed (copy these to another system as required). To use the same system enter `rmi://localhost/` for the **Remote Server URL** field. To display the plots on a different system, change `localhost` to an appropriate value that will resolve to the Internet Protocol (IP) address of the system where the RMI Registry and SPPlotServer are located. Alternatively, just use the actual IP number.

To start the RMI Registry, a batch file or UNIX shell script can be constructed, because the RMI Registry program is required to have in its classpath the locations of files referenced by server Processes. Here are some examples of what should be contained in those files:

Windows batch file:

```
set CLASSPATH=SPRemote.jar
rmiregistry
```

UNIX shell script using the Bourne shell or a derivative:

```
CLASSPATH=SPRemote.jar
export CLASSPATH
rmiregistry
```

UNIX shell script using the C shell or a derivative:

```
setenv CLASSPATH SPRemote.jar
rmiregistry
```

Sample batch files and scripts are located in the `SPUser\SampleFiles` directory. `SPUser` is in the directory where SIMPROCESS was installed. The sample batch files and scripts are intended to be used in the SIMPROCESS installation directory.

Adjust the precise CLASSPATH value as needed, based on where the copy of `SPRemote.jar` is located and the current working directory. Once the RMI Registry program is started, SPPlotServer can then be started. When using `localhost`, enter this command from the SIMPROCESS directory on the system where SIMPROCESS is installed:

```
jre\bin\java -classpath SPSYSTEM\SPRemote.jar;SPSYSTEM\plot.jar
com.caci.remote.SPPlotServer
```

Alternatively, the `PlotServ` batch or script file in the `SPUser\SampleFiles` directory can be run. Simply copy the appropriate file to the SIMPROCESS installation directory before running.

If not using `localhost`, from the directory where SPRemote.jar and plot.jar are located, enter this command:

```
jre\bin\java -classpath SPRemote.jar;plot.jar
com.caci.remote.SPPlotServer
```

Use colons in the classpath for non-Windows systems. Once the Java RMI Registry and SPPlotServer have been started, load and run the model.

Note that remote plots are not plotted locally. Real-time plots are created either locally or remotely, but not both. Remote real-time plots cannot be hidden (even if selected in the Real-Time Plot Properties). That is, they will display as soon as simulation data is sent to the plot. Also, once a remote real-time plot has been closed, there is no way to reopen it since remote real-time plots are not in the list of plots available through the **Display Real-Time Plots** button or menu item.

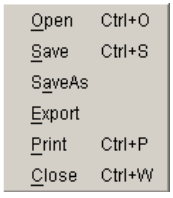
Automatic Saving of Plots

Plots are automatically saved in the `plots` directory (which is created under the `SPUser` directory) at the end of a simulation run. Only local plots are saved. All plots are saved using the name of the plot as the name of the file. When creating the file name, some special characters (:, !, @, #, $, %, ^, &, *, /, and \) in the name of the plot are replaced by underscores. Note that not all special characters are replaced, and, depending on the system and the special characters, special characters that are not replaced with underscores could cause an error during the automatic save of the plot. Trace plots have a `.trc` extension and histogram plots have an `.hst` extension. These plots will be overwritten each time the model is run. Thus, if a plot file needs to be saved, it should be renamed or moved, or the plot can be saved using the **File/Save** option. **Launch Plot Application** on the Report menu opens a plot window. Saved plots can be opened using the **File/Open** option of the plot window.

Post Plotting Options

Each plot window has a menu and four buttons. These provide options to save, print, and format plots. Also, the plots have a zoom capability.

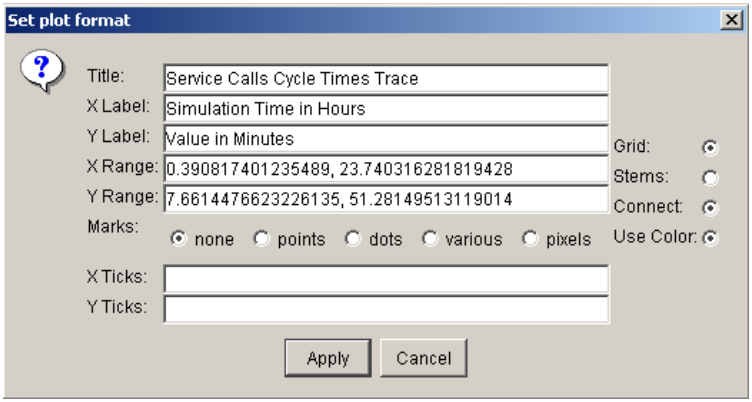
File Menu



- **Open** - Opens a previously saved plot
- **Save** - Saves a plot in XML format
- **SaveAs** - Saves a previously saved plot under a new name
- **Export** - Saves the plot as an encapsulated postscript file
- **Print** - Prints the plot
- **Close** - Closes the plot window.

Edit Menu

- **Format** - Changes the format of the plot



Special Menu

- **About** - Lists information on plot developers
- **Help** - Limited information on zooming plots
- **Clear** - Erases the values plotted
- **Fill** - No effect on plot
- **Reset Axes** - Resets axes ranges to starting values
- **Sample Plot** - Displays sample plot.

Plot Buttons

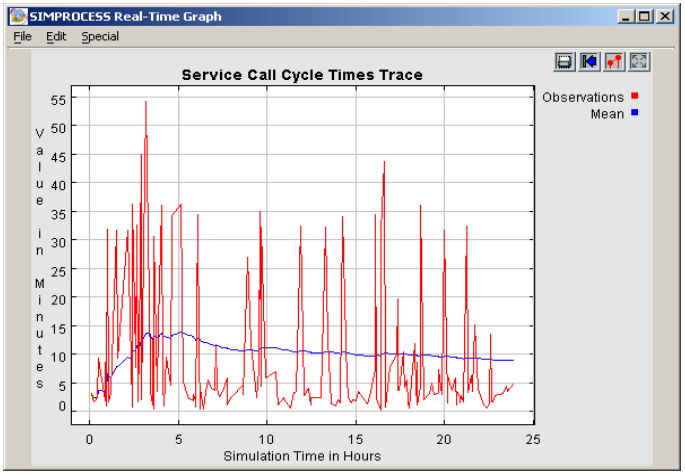
Button functions, as seen from left to right, are as follows:

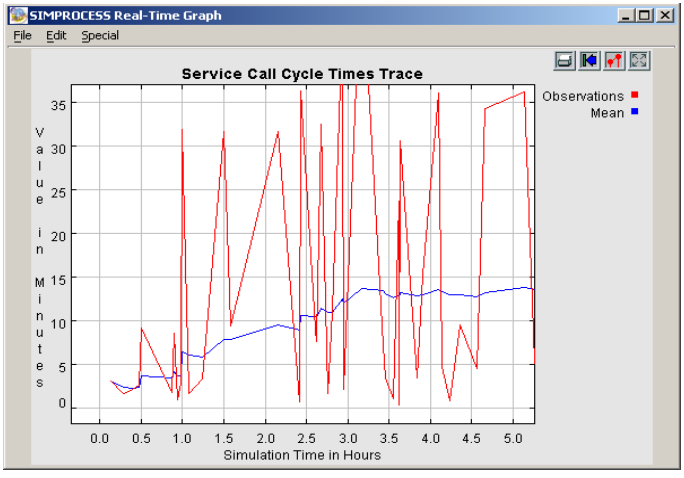
- Prints the plot. (Same as **File/Print**.)
- Resets the X and Y ranges to their original values. (Same as **Special/Reset Axes**.)

- Sets the plot format. (Same as **Edit/Format**.)
- Rescales the plot to fit the data. Used after zooming to return to full view of plot.

Plot Zooming

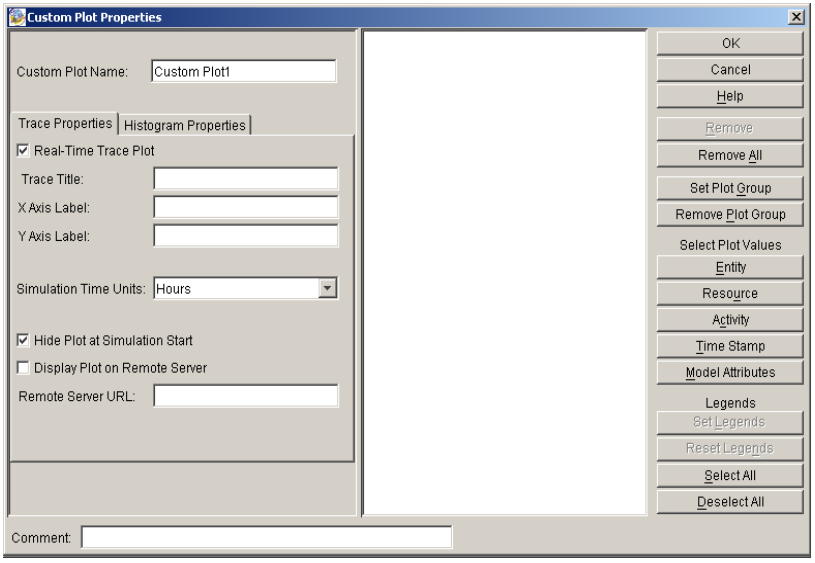
Once the simulation is complete, portions of the plot can be zoomed. To select the area for zooming, left mouse click at one corner of the area and drag over the area. When the mouse is released, that area will fill the plot. The following two plots demonstrate this. The first plot is the original plot. The second shows the plot with a portion zoomed.


SIMPROCESS Real-Time Graph
File Edit Special
Service Call Cycle Times Trace
Observations
Mean
Value in Minutes
0 5 10 15 20 25 30 35 40 45 50 55
0 5 10 15 20 25
Simulation Time in Hours


SIMPROCESS Real-Time Graph
File Edit Special
Service Call Cycle Times Trace
Observations
Mean
Value in Minutes
0 5 10 15 20 25 30 35
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Simulation Time in Hours

Custom Plots

The real-time trace plots available from **Define Real-Time Plots** on the **Report** menu plot one value along with its mean. **Define Custom Real-Time Plots** offers the option of selecting more than one value to be on a trace and/or histogram plot. Thus, various values can be viewed in comparison with one another on the same plot. Selecting **Define Custom Real-Time Plots** brings up a dialog that lists the custom plots defined in the model. Clicking the **Add** button brings up a dialog that has the trace and histogram plot properties on the left and the list of values to plot on the right. Note that if a trace plot and histogram plot are selected, the values plotted are the same for both plots. Another custom plot must be defined if different values are to be on the trace plot and histogram plot. The plot properties on the left are the same as described on page 178.

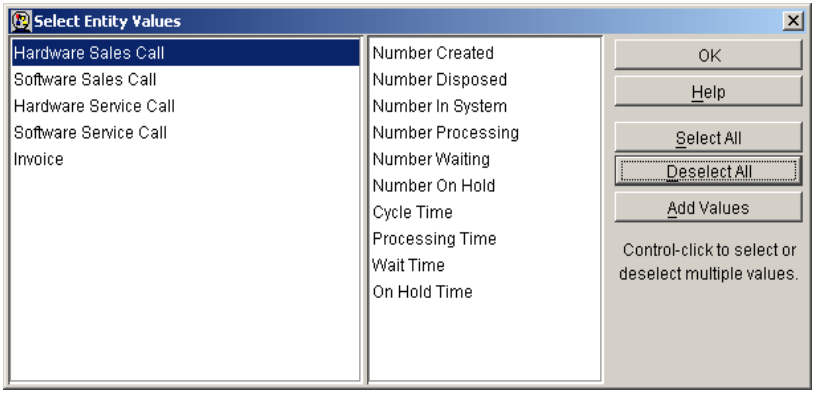


Adding Values To Custom Plot

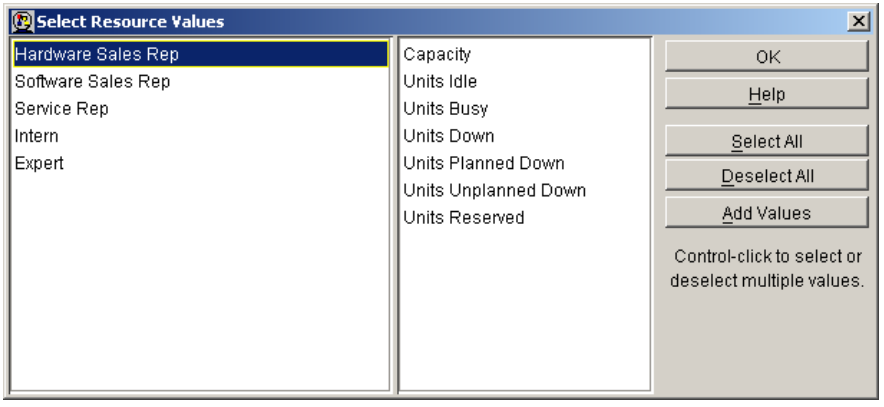
The buttons located under **Select Plot Values** of the Custom Plot Properties dialog determine which values will be plotted in the trace and/or histogram plots. The buttons are **Entity**, **Resource**, **Activity**, **Time Stamp**, and **Model Attributes** buttons. These buttons bring up the appropriate list of items along with the values that can be plotted.

Entity - displays a list of Entities defined in the model. Once an Entity has been selected, the values for plotting appear. The values that can be plotted are Number Created, Number Disposed, Number In System, Number Processing, Number Waiting, Number On Hold, Cycle Time, Processing Time,

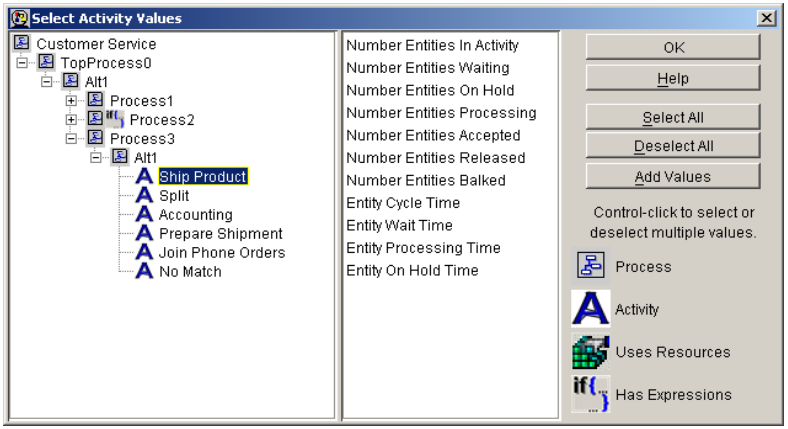
Wait Time, and On Hold Time.



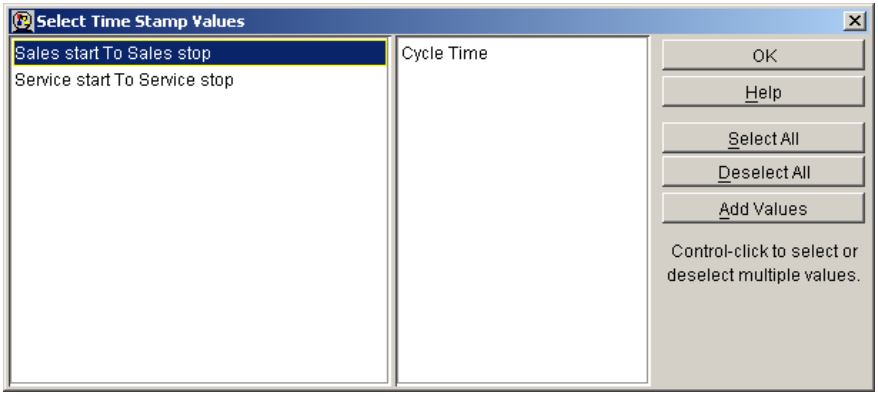
Resource - displays a list of Resources defined in the model. Once a Resource has been selected, the values available for plotting appear. The values that can be plotted are Capacity, Units Idle, Units Busy, Units Down, Units Planned Down, Units Unplanned Down, and Units Reserved.



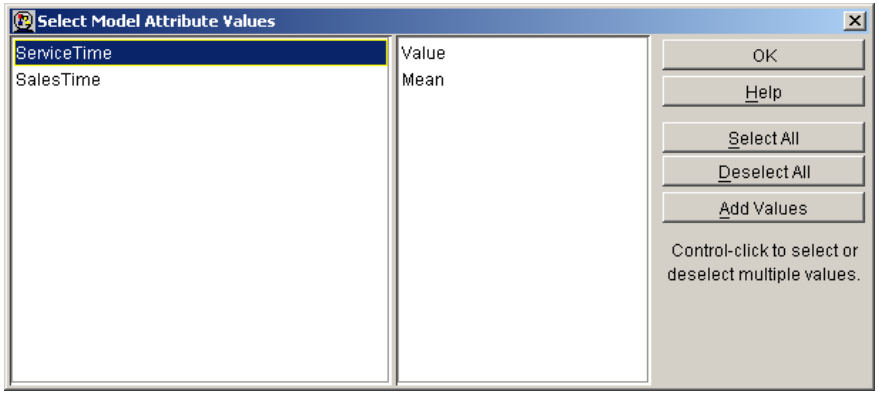
Activity - displays a hierarchical tree of the model. Once a Process or Activity has been selected, the values available for plotting for that item appear. The values that can be plotted for Processes are Number Entities In Process and Entity Cycle Time. The values that can be plotted for Activities are Number Entities In Activity, Number Entities Waiting, Number Entities On Hold, Number Entities Processing, Number Entities Accepted, Number Entities Released, Number Entities Balked, Entity Cycle Time, Entity Wait Time, Entity Processing Time, and Entity On Hold Time.



Time Stamp - displays the Time Stamps defined in the model. Once a Time Stamp has been selected, the only value available for plotting is Cycle Time.



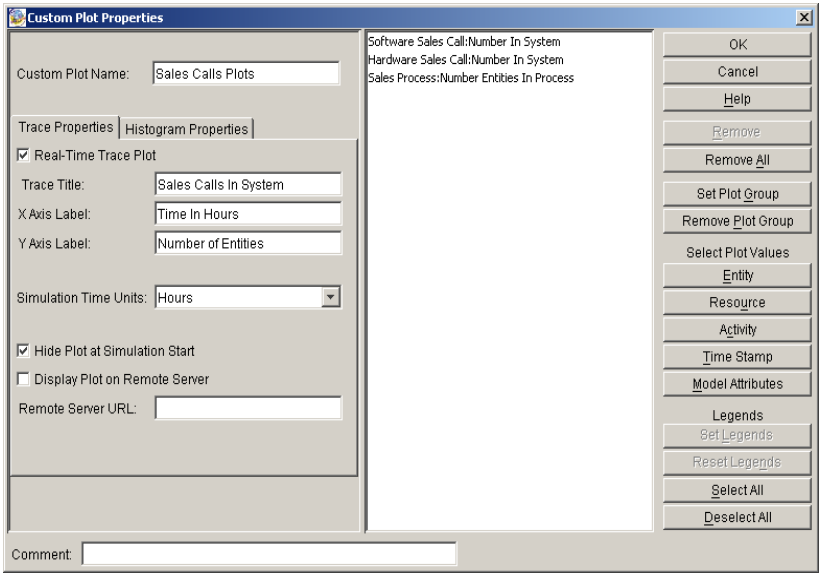
Model Attributes - displays a list of the **Integer** and **Real** Model Attributes defined in the model. Array attributes are listed by element. Once an attribute has been selected, the values available for plotting appear for that attribute. The values that can be plotted are the Value of the attribute and the Mean of the attribute. The Mean is the observation mean.

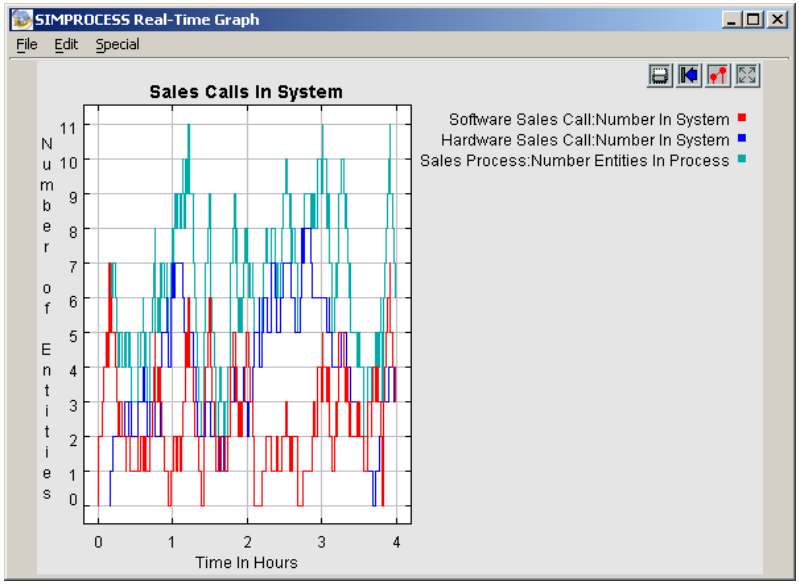


Values can be added to the plot from each type (Entity, Resource, etc.). However, adding values from different types and within types must be done with care. The units for each of the values should match. For instance a cycle time should not be plotted along with a number of Entities value (for example, Number In System). Those types of values have different units.

To add values, select the item on the left and the values desired on the right. Only one item on the left can be selected at a time. However, multiple values on the right can be selected. If all are desired, the **Select All** button can be used. Once selections are made, click the **Add Values** button. If the **Add Values** button is not clicked, no values for plotting are added. Thus, multiple values from the items on the left (Entity, Resource, etc.) can be added to the trace before clicking **OK**. Note that statistics do not have to be collected on the values selected for the values to plot.

The custom plot below plots three values: two Entity and one Activity. Hardware Sales and Software Sales are Entities. The value Entities In System is being plotted for both. Sales Process is a Process. The value Number Entities In Process is being plotted for it. All three of these values have the same units (number). Only a trace plot is defined. Following the dialog is the actual plot.


Custom Plot Properties
Custom Plot Name:
Sales Calls Plots
Trace Properties
Histogram Properties
Real-Time Trace Plot
Trace Title:
Sales Calls In System
X Axis Label:
Time In Hours
Y Axis Label:
Number of Entities
Simulation Time Units:
Hours
Hide Plot at Simulation Start
Display Plot on Remote Server
Remote Server URL:
Comment:
Software Sales Call:Number In System
Hardware Sales Call:Number In System
Sales Process:Number Entities In Process
OK
Cancel
Help
Remove
Remove All
Set Plot Group
Remove Plot Group
Select Plot Values
Entity
Resource
Activity
Time Stamp
Model Attributes
Legends
Set Legends
Reset Legends
Select All
Deselect All


SIMPROCESS Real-Time Graph
File
Edit
Special
Sales Calls In System
Number of Entities
Time In Hours
Software Sales Call:Number In System
Hardware Sales Call:Number In System
Sales Process:Number Entities In Process

Removing Values From Custom Plot

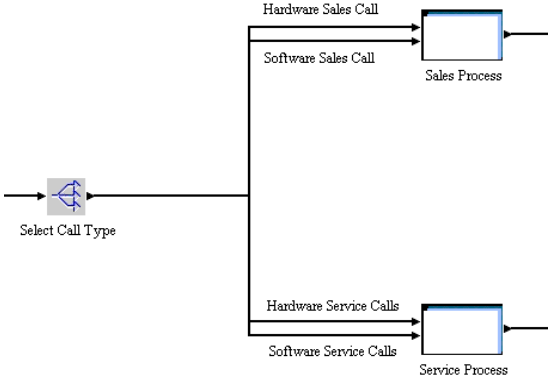
Removing values from a custom plot is accomplished from the Custom Plot Properties dialog. There are two buttons for removing values: **Remove** and **Remove All**. The **Remove All** button clears the plot of all values. The **Remove** button clears the values that have been selected. More than one value can be selected by holding down the Control key when selecting.

Setting and Removing Plot Group

Custom plots can be assigned to groups. Groups are based on Activities and Processes. A plot can be assigned to any group but can only belong to one group. Plot groups only apply to custom plots or Activity/Process plots from **Define Real-Time Plots/Activities** on the **Report** menu. (See "Real-Time Plots" on page 176.)

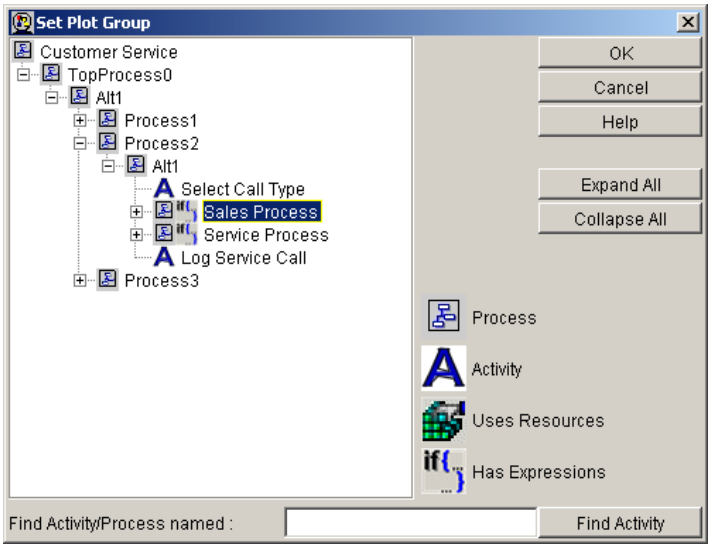
Setting Plot Group

Plot groups allow custom plots to be associated with a particular Process or Activity, and they limit the number of plots in the **Display Real-Time Plots** dialog. The latter can be valuable if there are many custom plots and/or Activity plots defined in a model. **Display Real-Time Plots** on the **Report** menu or the tool bar brings up a dialog that lists all of the hidden plots in the model. This list can be restricted by assigning custom plots to groups. For instance, below is a portion of a model that models hardware and software sales and hardware and software service. There are two subprocesses: Sales Process and Service Process.

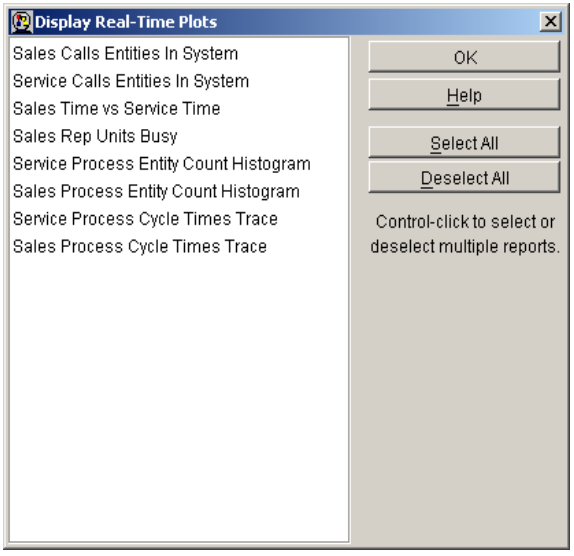


Plots can be assigned to these Processes so that, when one of the Processes is selected, only the plots assigned to its group appear when **Display Real-Time Plots** is selected.

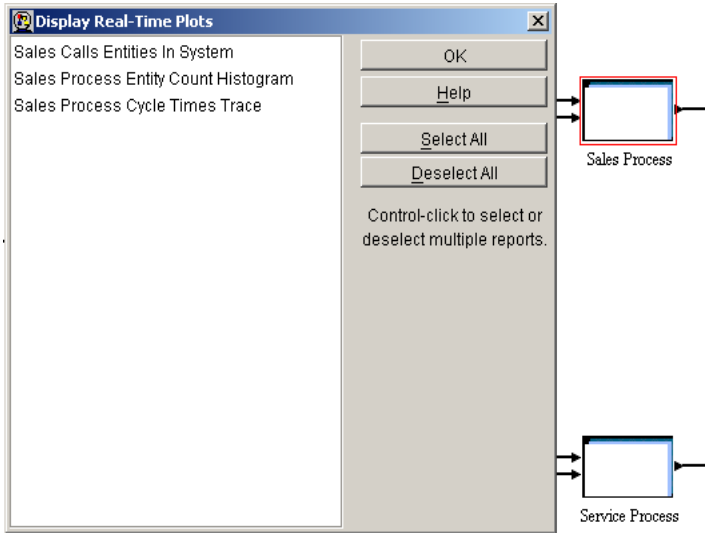
To set the plot group, click the **Set Plot Group** button on the Custom Plot Properties dialog. This opens a dialog that has the hierarchical view of the Activities and Processes in the model (similar to the Activity Browser dialog from the **Edit** menu). The item selected when **OK** is clicked is the group to which the plot is assigned. Plots cannot be assigned to the model, TopProcess, or a Process alternative. If one of those is selected when **OK** is clicked, the plot is not assigned to a group.



As an example, all the plots chosen to be hidden in the Customer Service model are shown below. This list was displayed after the model was run using the Display Real-Time Plots button on the tool bar.

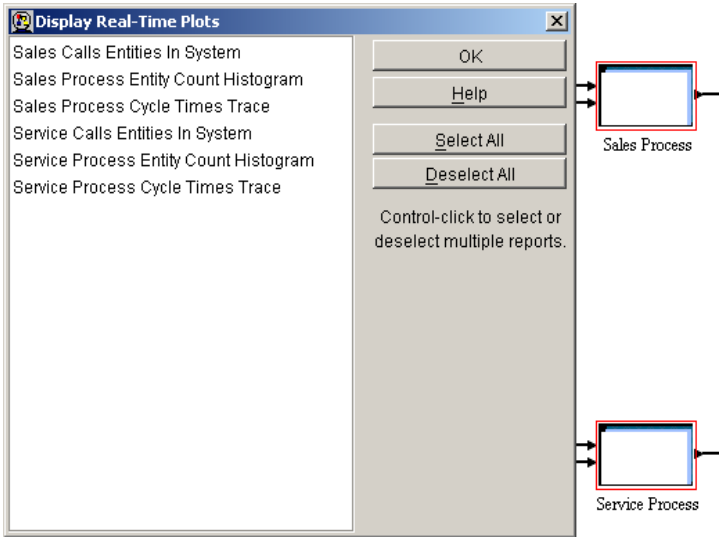


By selecting the Sales Process, this list can be restricted to the plots in the Sales Process group.



The list includes one custom plot (Sales Calls Entities In System) and two Activity plots from **Define Real-Time Plots** on the **Report** menu (Sales Process Entity Count Histogram and Sales Process Cycle Times Trace).

Selecting the Sales and Service Processes causes the list to include plots assigned to both Processes.



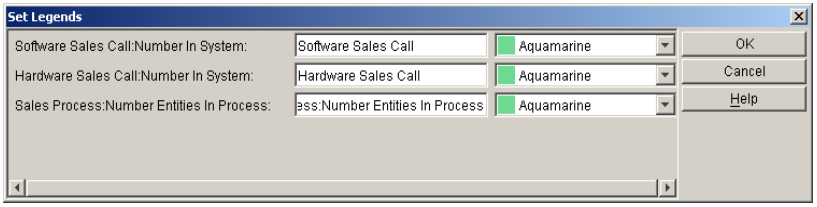
Removing Plot Group

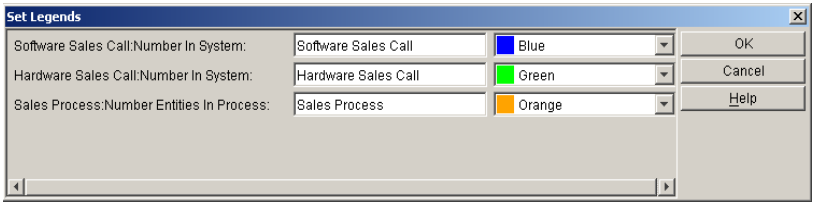
A plot can be removed from a plot group by either changing the assignment using the **Set Plot Group** button or using the **Remove Plot Group** button on the Custom Plot Properties dialog. The **Remove Plot Group** button simply removes the plot from the group, and no reassignment occurs. The button does nothing if the plot is not assigned to a group.

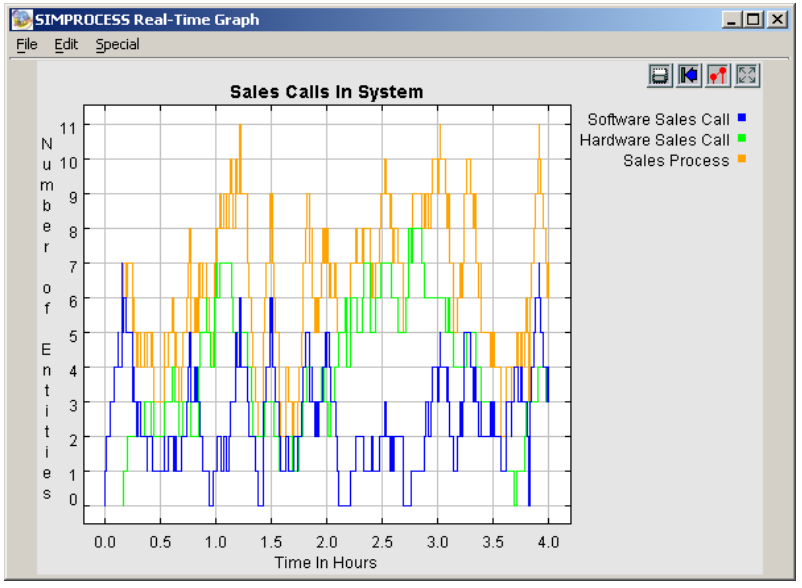
Setting Legends

The legends on custom plots default to the names of the values in the plot (for instance, Software Sales Calls:Entities In System). The **Set Legends** button allows the legend title to be changed. Also, the color of the trace line can be changed. When one or more values in the custom plot have been selected, the **Set Legends** and **Reset Legends** buttons become active. The **Select All** button selects all values in the custom plot, and the **Deselect All** button deselects all values in the custom plot.

The **Set Legends** button brings up a dialog in which the text of the legend and the color of the trace line can be set. Only the values selected will be in the dialog. Double clicking on a single value will bring up the dialog with just the options for that value. The color of the value must be set if the text of the legend is set. If not, the color will be Aquamarine, which is the first color in the color list.







The **Reset Legends** button resets the text and color of the legend to its default.

Simulation Results File

The Simulation Results file is generated from the **File** menu. Select **File/Export/Simulation Results** to open the **Save Statistics** dialog. The Simulation Results file will, by default, have an `.xpt` file extension and be saved to the current model directory. This file is tab-delimited and can be opened using a text editor or spreadsheet.

The file will contain the complete statistical measures corresponding to the reports selected for the current model. This file contains raw statistical data that is displayed in the Standard and Custom Reports in a standard format that can be opened by many different applications.

For a complete listing of the format of the Simulation Results file, see "Simulation Results File," beginning on page 504

Part B
Advanced SIMPROCESS Functions and Features

The chapters in this section describe the advanced functions and features available in SIMPROCESS Professional.

CHAPTER 9

Reusable Templates and Libraries

One of the most powerful features of SIMPROCESS is the reusable Template. A template is an Activity, hierarchical Process, Resource, or Resource Downtime that is defined and reused over and over. A template library is a collection of templates that can be saved and loaded before starting a modeling session. The SIMPROCESS Template Library contains many model building and analysis support features. A standard set of Templates, such as Activities, Processes, Resources, and Resource Downtimes, are provided by the system. For example, specialized Resources such as Tellers, Loan Officers, Branch Managers can be defined in the Resource Library for Business Process Modeling in a financial services business. A Library could also contain templates that may represent competing models of the Business Processes that are being compared. Templates also provide the ability to set default parameters for system-provided items.

Many different Templates can be created and loaded into the system when they are needed. Customized Processes/Activities can be added to the User Palette bar (for easy reuse) and/or added to the **Create** pull-down menu.

Library Concepts

The SIMPROCESS Template and Library feature supports the reuse and organization of the various constructs used in building models.

The development of specialized objects organized into libraries is encouraged. Over time, the libraries of objects will grow. With a large set of libraries of reusable model building blocks, new models can be built faster. For example, a set of Processes (Warehouse, Manufacture, Transport) and Resources (Trucks, People, etc.) relevant to the Distribution domain can be created and saved to a library named Distribution. These can then be used to quickly build distribution models.

Libraries built can be saved and loaded during the modeling session as they are needed. The import and export features enable the sharing of templates with colleagues and increases the building blocks available for model construction.

In addition to providing a repository for storing categories of modeling constructs, the Library Management facilities can be used to customize defaults for model elements that are built into SIMPROCESS (statistical distributions, Activity parameters, etc.) Processes and Activities that are used frequently can be kept on the User Palette bar for quick access. Processes and Activities that are used less frequently can be accessed through the **Create** pull-down menu.

In summary, Templates:

- Are repositories for model building constructs created by the user
- Allow customizing of model elements through parameter settings
- Facilitate reuse of Processes, Activities, Resources, and Resource Downtimes
- Allow placement of Processes and Activities on the User Palette bar and the **Create** pull-down menu
- Allow the grouping of Processes and Activities in user-defined templates
- Facilitate importing and exporting of customized model elements for use in other models or by colleagues.

Defining and Editing Templates

The **Define/Templates** pull-down menu provides access to various options for manipulating templates. The two functions available under this pull down menu are **Add** and **Library Manager.**

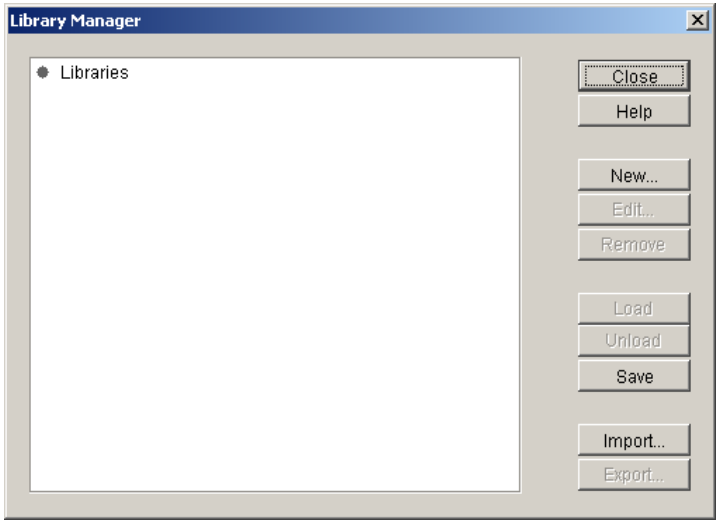
Add adds the selected Process or Activity from the workspace to the library. It also sets whether the Process or Activity is added to the User Palette or the **Create** menu.

Library Manager brings up the SIMPROCESS Library Manager. The Library Manager is used to create, load, save, remove, edit, import, and export libraries of templates

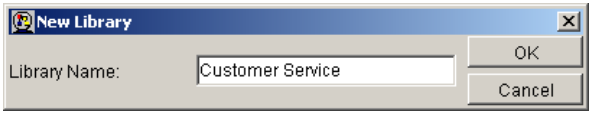
Using The Library Manager

Library Management

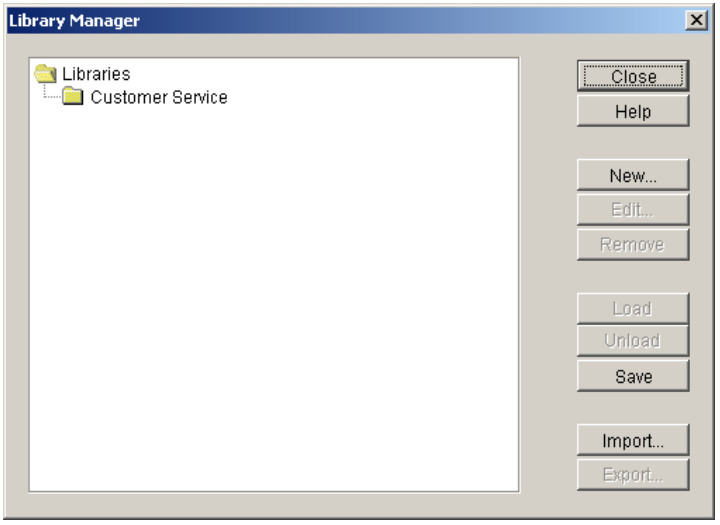
The Library Manager is the primary tool for managing templates. Before creating templates, a library should be created. When no libraries exist, the Library Manager is empty.



New creates a new library in which templates can be stored. A dialog for entering a name appears.



When OK is selected, the new library appears in the library manager. This new library is empty at this point, but templates can now be stored in it.

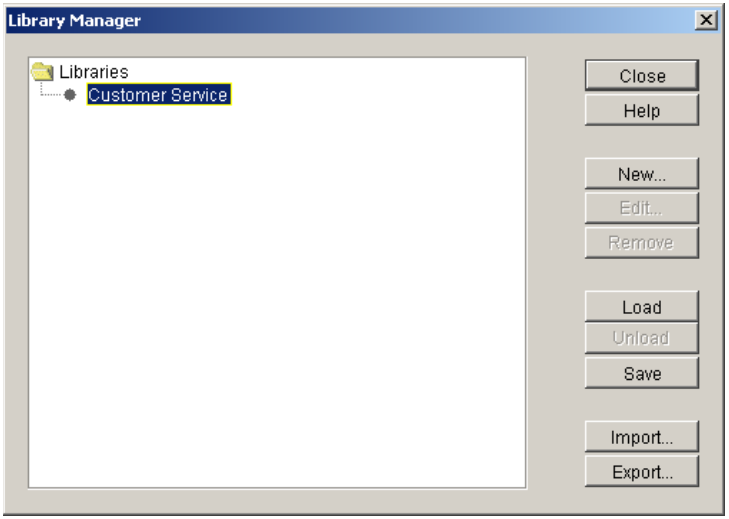


Edit allows the editing of the library name if a library is selected. If a template is selected, **Edit** allows the editing of template options, which includes the template name.

Remove deletes the selected item. If a library is selected, the library and all templates in the library are deleted. If a template is selected, then only that template is deleted from its library.

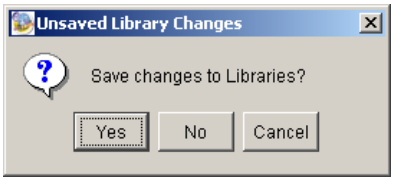
Load brings a library that has been previously saved into the current SIMPROCESS session. The templates can then be used to build models.

All libraries that have been saved will be shown in the Library Manager. A dot by the library means the library has not been loaded. A folder by the library means that it has been loaded. Simply select the desired library and click **Load**.



Unload removes a library from the current SIMPROCESS session.

Save saves a template library for future use. When the Library Manager or SIMPROCESS is closed, there will be a prompt to save libraries if there are libraries that have not been saved.



Import imports a library file that was exported by another SIMPROCESS user.

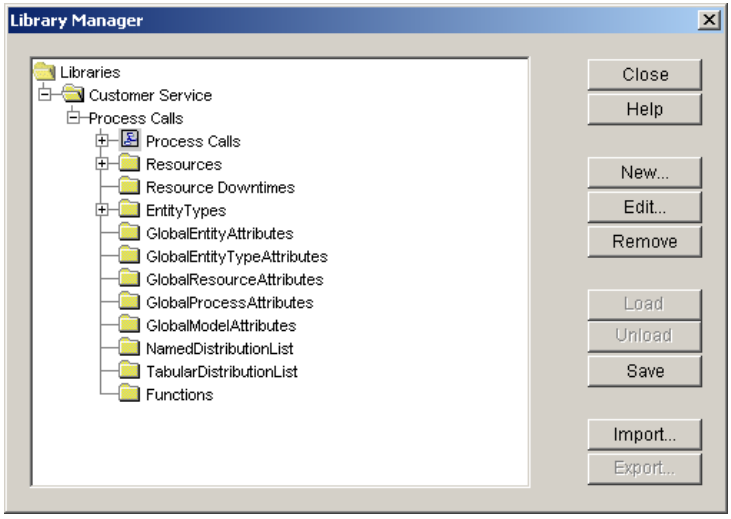
Export exports a library file that another SIMPROCESS user can import.

Template Structure

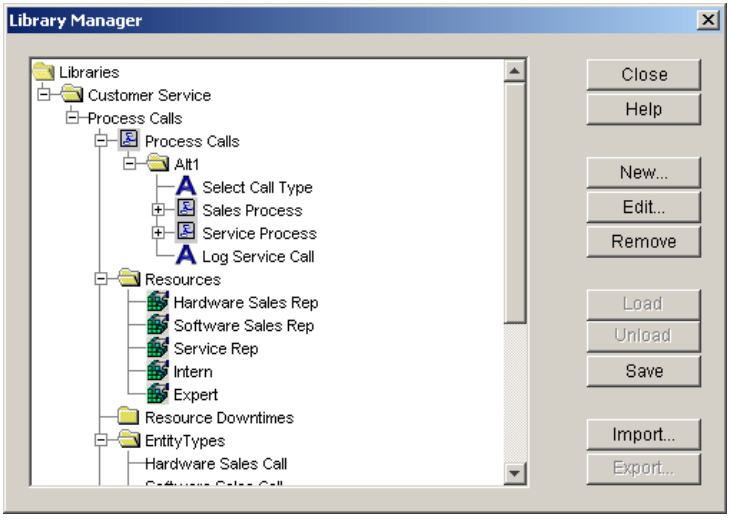
All elements of a Process or Activity template can be viewed from the Library Manager. Process templates include all the Processes and Activities that were a part of the Process. Activity templates include the Activity itself. Both types of templates contain other elements that were referenced by the Process or Activity placed in the library. These elements include Resources, Resource Downtimes, Entity Types, global Entity Attributes, global Entity Type Attributes, global Resource Attributes, global

Activity Attributes, named distributions, tabular distributions, and Functions. Note that code stored in a file for an Expression in a Process or Activity template or code stored in a file for a Function referenced is not included in the template. The file references are included in the template, but the template does not carry the files or their content with it.

The figure below shows a template named Process Calls in the Customer Service library.

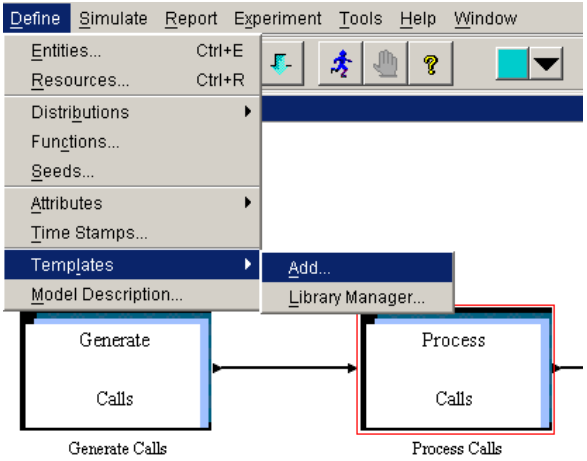


The elements with a "+" can be expanded to see the items included. A partially expanded view is shown below.

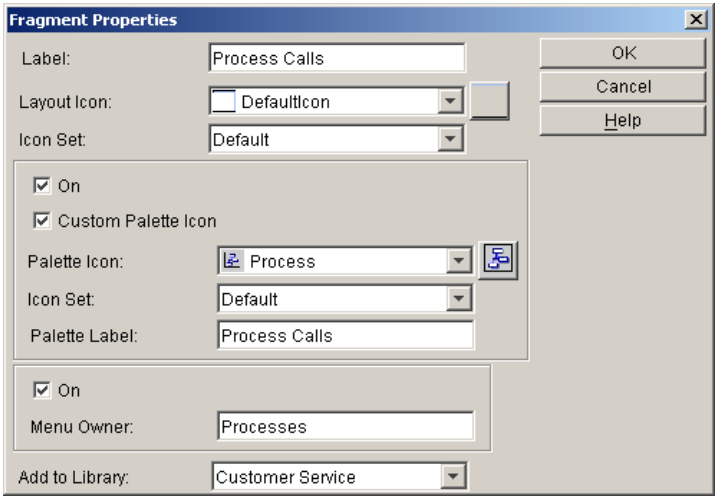


Adding a Process/Activity Template

To create a Process or Activity template, select the Process or Activity in the model, and choose **Templates/Add** from the **Define** menu.



This brings up a dialog where the template options can be set.



Label is the name of the template that will be stored in the selected library.

Layout Icon is the icon that will display when the template is used in a model.

Palette Parameters determine the User Palette settings. If On/Off is checked, the template will appear on the User Palette. The User Palette is on the right side of the screen. If Custom Palette Icon is selected,the Palette Icon list is active.

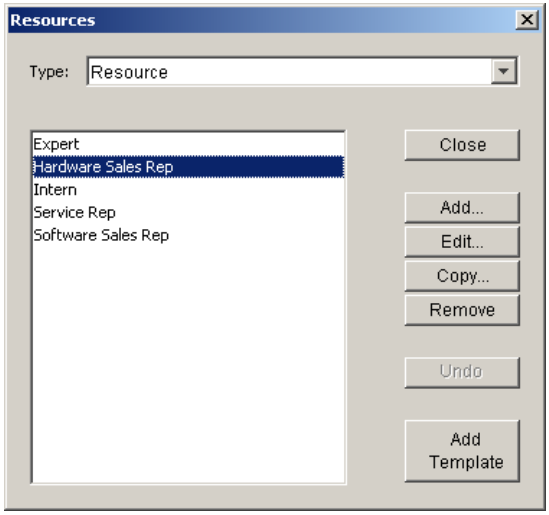
The icon for the template on the User Palette is selected from the Palette Icon list. The Palette Label is the tool tip that will appear when the mouse is over the palette icon.

Menu Parameters determine the menu placement of the template. If **On/Off** is selected, the template will appear on one of the **Create** sub-menus with the name from the **Label** field. **Menu Owner** sets the sub-menu for the template. One of the current sub-menus can be used or a custom menu name can be entered.

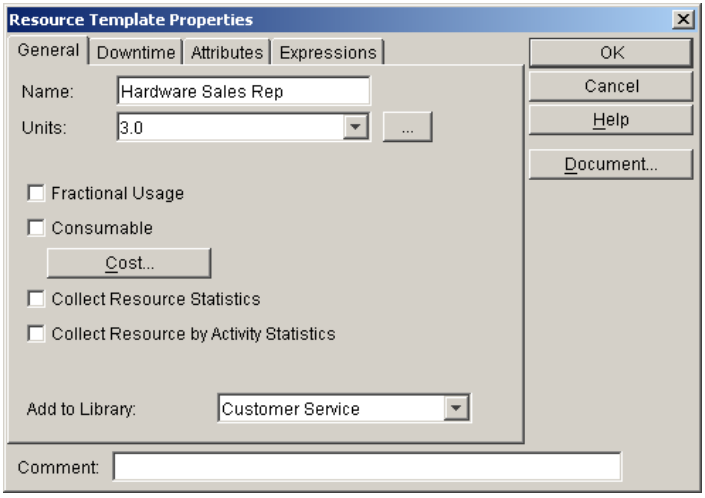
The library that this template should be added to is selected from the **Add to Library** list. If no library has been created, then the template will be added to a library named *Default.*

Adding Resource Templates

Resource templates are created from the Resource list box. The Resource list box displays all the resources defined in the model. It is accessed from **Resources** on the **Define** menu. The Resource list box has an **Add Template** button.



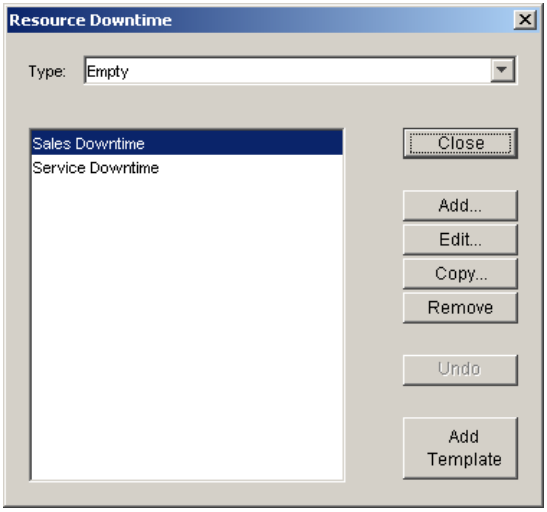
Select the Resource and click the Add Template button. This brings up the properties of the template.



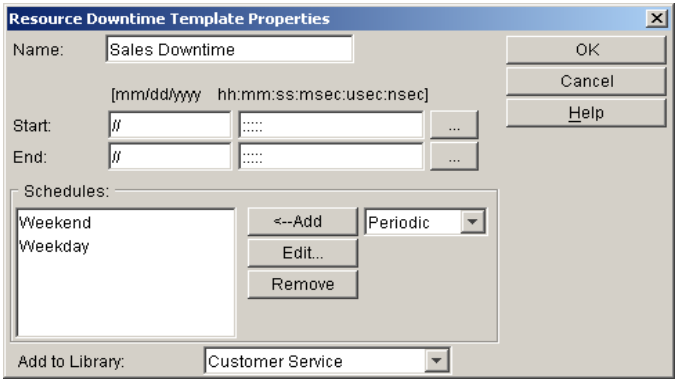
The template properties are simply the Resource properties with the **Add to Library** option added. As with the other template types, if there has not been a library defined, the Resource template will go into the *Default* library.

Adding Resource Downtime Templates

Resource templates are created from the Resource Downtime list box. The Resource list box displays all the resource downtimes defined in the model. It is accessed from **Resource Downtimes** on the **Define** menu. The Resource Downtime list box has an **Add Template** button.



Select the Resource Downtime and click the Add Template button. This brings up the properties of the template.



The template properties are the Resource Downtime properties with the Resource assigments removed and the **Add to Library** option added. As with the other template types, if there has not been a library defined, the Resource Downtime template will go into the *Default* library.

Editing Templates

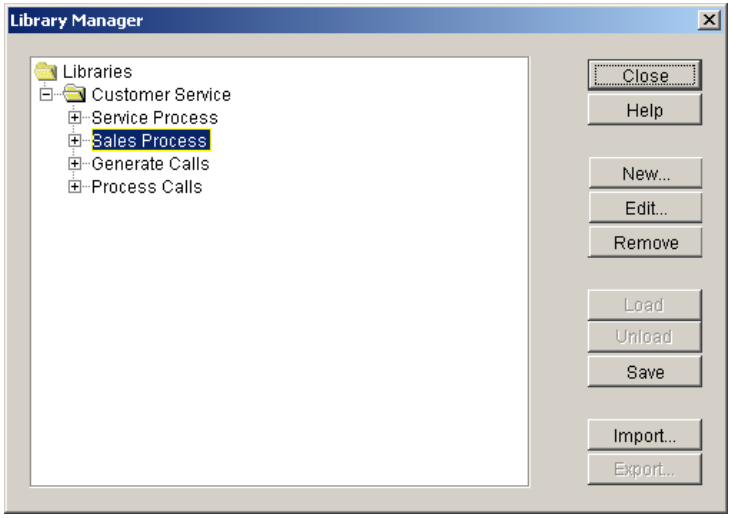
Templates cannot be edited directly from the Library Manager. However, template library parameters can be edited from the Library Manager.

Editing Templates

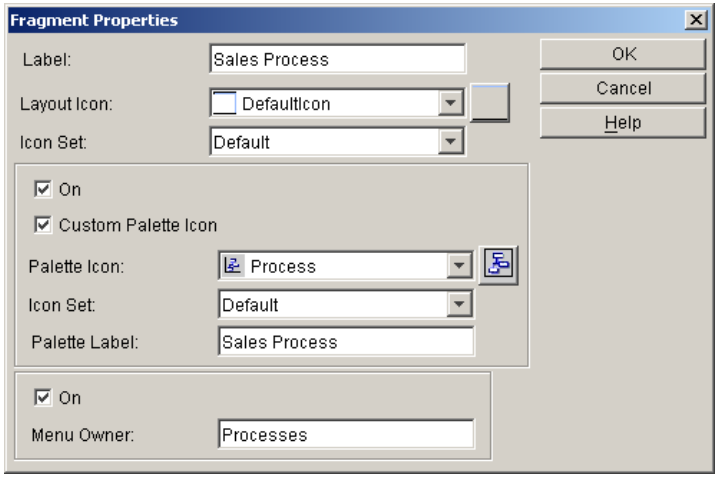
Templates can only be edited when they are part of a model. Thus, the way to change a template is to open a new model, place the template within the model, make the necessary changes, then add the changed template to the library. If the template is added with the same name, it replaces the original.

Editing Library Parameters

To change the library options for a template, select the template in the Library Manager and click the **Edit** button. This will bring up the same properties dialog that appeared when the template was added to its library. The only difference is that the library for the template cannot be changed.



Below are the template properties for *Sales Process*. Any property can be changed except the library owner. That field is missing. To place the template in a different library, it must be added to that library.


Fragment Properties
Label:
Sales Process
OK
Cancel
Help
Layout Icon:
DefaultIcon
Icon Set:
Default
On
Custom Palette Icon
Palette Icon:
Process
Icon Set:
Default
Palette Label:
Sales Process
On
Menu Owner:
Processes

Advantage of Templates Over Copy/Paste

Portions of models can be copied from one model and pasted into another model. However, the copy action only copies the Activity/Connector structure. References to Entities, Resources, Resource Downtimes, user defined distributions, Functions, or Attributes within the Activities are not carried because those items may or may not exist in the model in which the paste occurs. This means all those references must be redefined in the new model. When this occurs, a dialog will appear after the paste that lists the items that have invalid references. Those items can be edited from the list.

Templates also allow portions of one model to be used in another model. However, since templates carry references to the Entities, Resources, and Attributes used, those items remain referenced in the Activities. Those references do not have to be redefined in the new model.

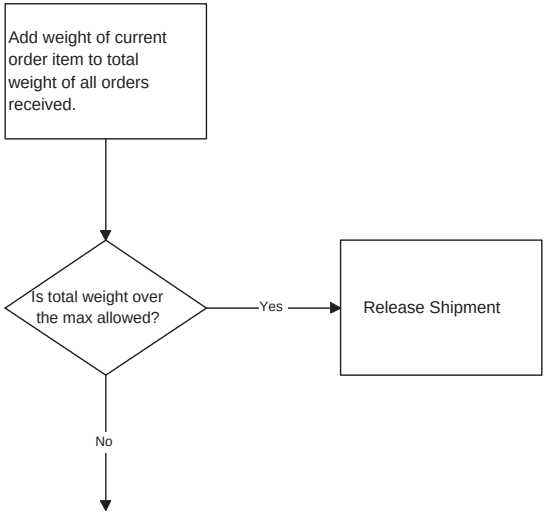
CHAPTER 10

Customizing a Model with Attributes and Expressions

SIMPROCESS provides a wide range of predefined model elements and statistical options, but every business Process is unique in some way. There will be times when flexibility is needed to model complex situations, and the built-in functions of SIMPROCESS may be inadequate. In those cases, Attributes and Expressions can be defined.

For example, a typical SIMPROCESS model for an appliance manufacturer's distribution Process might include a batch Activity where customer orders are collected for shipment. Products may be shipped on a predetermined schedule, or when the total number of pending orders reaches a certain number. The SIMPROCESS Batch Activity readily handles these scenarios with the **Quantity to Batch** and **Release Threshold** options.

But suppose the dispatching of a shipment depends on the total weight of the appliances that have been accumulated. How is this situation modeled?


Add weight of current order item to total weight of all orders received.
Is total weight over the max allowed?
Yes
Release Shipment
No

Customizing reports is another area where flexibility might be needed. SIMPROCESS provides several reports that track the flow of Entities through a model. The values for how many Entities of a particular type (each customer order, for example) are processed during simulation, or the average amount of time an Entity takes to make its way through the simulation are available in the Standard Report.

But suppose the percentage of orders that are shipped by a promised delivery date (service level) is needed to measure success in attaining service goals.

Two advanced SIMPROCESS features, *Attributes* and *Expressions*, provide the ability to handle these and many other situations.

Introduction to Attributes and Expressions

Attributes

Attributes are user-defined and built-in variables of model elements whose values can change during the course of a simulation run. For example, for a Batch Process where Entity release depends on the weight of the Entities received, an Attribute is the total weight of the items accumulated in the Batch Activity.

To determine the percentage of orders processed within a specified period of time, Attributes need to track the processing time for each order, the number of orders that meet the promised delivery date, and the total number of orders processed.

Attributes may be used to:

- Alter the behavior of a Process by changing the value of an Attribute during a simulation
- Communicate information (such as Attribute values) between two Processes in a model
- Store data collected during a simulation run.

There are two categories of SIMPROCESS Attributes: built-in *System Attributes*, which SIMPROCESS automatically creates and updates, and *User Defined Attributes*, which the user creates. For example, the number of Entities generated for each Entity type (e.g., number of orders) is automatically tracked and stored in a built-in system Attribute named **`NumberCreated`**. To track an Attribute such as weight, which SIMPROCESS does not know about, an Attribute called **`applianceWeight`** could be created.

Some system Attributes can be modified by users. These are called “Get-Set” type System Attributes. Generally, these are variables that control Process parameters such as the number of Entities to batch or amount of time of the next delay. By modifying these system Attributes, the behavior of the simulation can be affected.

System Attributes that cannot be changed include those that monitor statistics, such as the number of Entities generated during the simulation. These are called “Get-Only” type System Attributes. Information on the status of a simulation, such as which Activity is processing an Entity or what type of Entity is being processed, is also available through “Get-Only” system Attributes.

See “SIMPROCESS System Attributes and Methods,” beginning on page 458 for a complete list of System Attributes.

Expressions

Attributes are a powerful simulation feature when used in conjunction with SIMPROCESS Expressions. Expressions are user-written statements that SIMPROCESS executes during a simulation run. Expressions are defined at the point at which the Expression is to be evaluated; for example, at the beginning of the simulation, or at the moment an Entity (e.g., a customer order) is received by an Activity (e.g., order distribution).

In the case of the model where releasing of shipments depends on the total weight of orders such as appliances, the following could be done:

1. An Attribute called **`applianceWeight`** could be defined and its value set whenever an appliance-order Entity is generated by SIMPROCESS. The value to assign **`applianceWeight`** would be determined by checking the name of the Entity type (e.g., dishwasher-order, television-order). This information is available from the System Attribute **`Name`**.
2. When an Entity is received at the Batch Activity, the Entity's **`applianceWeight`** value would be added to the total weight of all orders waiting to be shipped (another User Attribute). The total weight would then be checked. If it exceeds a certain value, the Batch Activity would be forced to release a shipment.

One way to force a shipment to be released is to change the batch size to a value equal to the current number of Entities in the Batch Activity. These values are available in System Attributes.

This chapter describes:

- Built-in System Attributes
- User-Defined Attributes
- How to write an Expression which uses User-Defined Attributes and System Attributes.

Using Attributes in SIMPROCESS

This section contains a closer look at Attributes and how they can be used in SIMPROCESS. It starts with a look at the system Attributes built into SIMPROCESS and then goes on to a detailed discussion of User-Defined Attributes.

System Attributes

SIMPROCESS provides access to the state of a simulation through a set of built-in variables. These System Attributes provide information such as:

- The type of Entity currently in an Activity
- The number of Entities of a particular type that have been generated thus far in the simulation
- The name of the Activity holding a particular Entity
- The type of Entity being generated by a Generate Activity.

A complete list of System Attributes is given in "SIMPROCESS System Attributes and Methods," beginning on page 458. The table entries below show the Attributes accessible from Batch Activities:

Object	Name	Type	Get/ Set	Description
Batch Activities	MaxBatchSize	INTEGER	Both	Number of Entities to batch.
	MinBatchSize	INTEGER	Both	Number of Entities must be in a batch before it can be released.
	MaxWaitTime	REAL	Both	Time to wait before releasing an undersized batch.

1. The *MaxBatchSize* Attribute is an integer value representing the maximum number of Entities to batch at a Batch Activity. The current value of the Attribute can be retrieved and changed.
2. The *MinBatchSize* Attribute is an integer value containing the minimum number of Entities a Batch Activity must hold before it can release a batched Entity.
3. The Attribute *MaxWaitTime* specifies the maximum amount of time to wait before releasing the batched Entities that have met the Activity's *MinBatchSize*. The value is a real number (e.g., 1.0, 7.5, etc.) representing the time unit selected for the maximum wait time. The value of this Attribute can be retrieved and changed.

User Defined Attributes

Customizing a model begins with defining Attributes. These Attributes can represent model element Attributes that are not built into SIMPROCESS, such as Entity weight and size or skill level of a Resource.

Attributes can be defined in association with:

- Entity types, or Entity instances
- Processes or Activities
- Resources
- The Model itself.

How an Attribute is defined tells SIMPROCESS whether to create an instance of that Attribute for every model element of the same type (e.g., Entities, Resources), or to just create the Attribute for a particular type of model element (customer order Entities, truck Resources). In SIMPROCESS terminology, Attributes are either *globally-defined* or *locally-defined*. Model Attributes are only globally-defined.

When an Attribute is defined globally, an instance of that Attribute is automatically created for each model element of that class. For example, if the model contains Entities of different types of appliances (refrigerators, televisions, toasters, etc.) and a weight value needs to be assigned to each Entity, a global Entity Attribute could be defined (*applianceWeight*). SIMPROCESS creates an instance of that Attribute for every Entity in the model, so every Entity has an appliance weight Attribute which can be referenced.

The only Activity concerned with weight is the Activity where Entities are batched. In this case, it makes sense to locally define an Attribute for that particular Activity. When that's done, no other Activity will have a weight Attribute automatically created for it.

Note that Attributes for different model elements can have the same name. For example, a global Attribute called *applianceWeight* could be defined for Resources. It can have a completely different meaning and data type. Global and local Attributes for the same model element cannot have the same name.

All attributes (global or local) are managed using a table similar to Entities and Resources. Changes to global attribute definitions from the table cannot be canceled. Each table can be sorted by a particular column by clicking the column header. Holding the **Shift** key while clicking the column header causes the sort to be in reverse order.

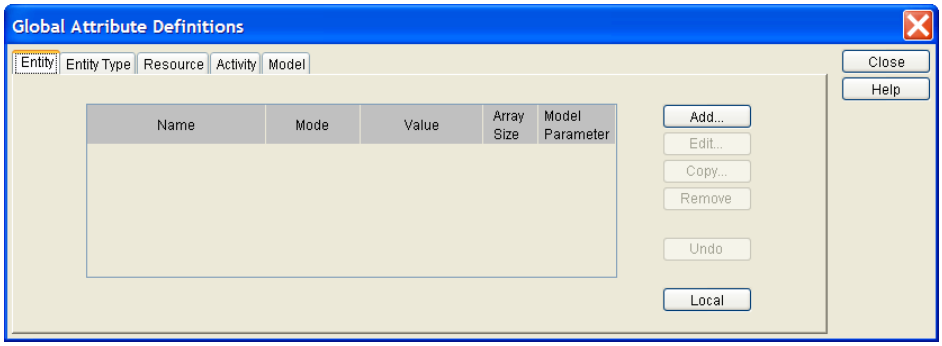
Creating a User Defined Attribute

Global Attributes can be defined from the SIMPROCESS menu or from the dialog of a model element.

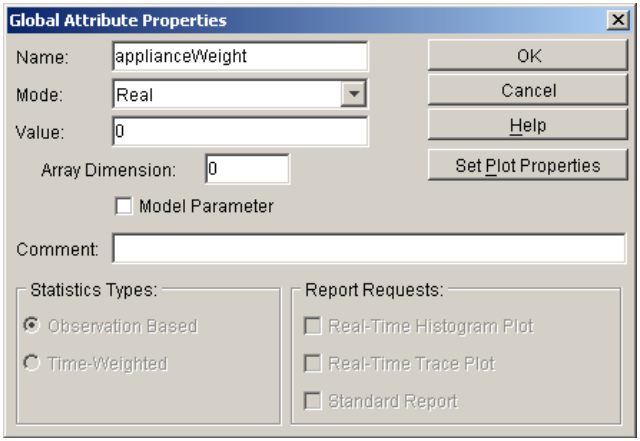
Local Attributes can only be defined from the dialog of a model element.

Globally Defining an Attribute from the Menu

To globally define an Attribute from the SIMPROCESS menu select **Global Attributes...** from the **Define** menu. The following dialog appears:



The **Global Attribute Definitions** dialog is used to add a new Attribute or to change, copy, or delete existing Attributes. There are five tabs: **Entity**, **Entity Type**, **Resource**, **Activity**, and **Model**. Each tab represents model elements for which global Attributes can be defined. Note that the **Entity** tab defines Attributes for each Entity instance created by the simulation. The originating Entity Type for the Entity instance is not considered. So every Entity instance created by the simulation will have an instance of each Attribute listed on the **Entity** tab. Attributes defined from the **Entity Type** tab are assigned to each Entity Type. That is, for all Attributes listed on the **Entity Type** tab, there is one of each Attribute created for each Entity Type that all Entity instances originating from that type can reference. Each tab shows the names of all Attributes of that type previously defined. If no Attributes have been defined, the list in each tab will be empty and the **Edit, Copy**, and **Remove** buttons will be inactive. The **Undo** button activates when an Attribute is removed. Select the **Entity** tab and click on **Add** to create a new Attribute.



In the **Attribute Properties** dialog:

Name can be anything (except as noted below), as long as the name has not been previously used for another Attribute of the same class of model element. For new Attributes, SIMPROCESS initializes the field with a default name.

Value is the default initial value of this Attribute. The value must correspond to the data type specified in the **Mode** field. For instance, 1.0 cannot be entered if the **Mode** is **Integer.** If the **Mode** is **Object**, the **Default** value is undefined. An **Object** Attribute's value can only be set during a simulation run. Anything entered in the **Default** field is ignored. (See **Mode** types below.)

Mode is the data type of the Attribute. Click on the arrow button to select either **Integer, Real, String, Boolean**, or **Object**:

Integer values are numbers without fractional or decimal parts.

Real values can contain fractional parts.

A **String** is any series of alphanumeric characters.

Boolean values can be either TRUE or FALSE.

An **Object** is a reference to another model element in the model. For example, during a simulation an **Object** Attribute to point to another Activity in the model.

Array Dimension allows for Attributes to be set up as an array. The default value of 0 means the Attribute is not an array. If an array dimension is provided and the user wishes to reference the Attribute in the Expression language, it must be done using an integer subscript (e.g., **`myattribute[2] := value;`**). The subscripted arrays are zero-based, meaning that a subscript of 0 refers to the first item in the array.

Model Parameter, when checked, means that every time the model is run, a dialog will open allowing new initial values to be entered for the Attribute. Only global, user-defined Attributes can be set as Model Parameters. If a **Comment** is entered for the Attribute, this will appear in the **Description** field of the Model Parameters dialog when the Attribute is selected.

Model Parameters can be changed during a simulation run by selecting **Change Model Parameters** from the **Simulate** menu. Note that changing the value of Model Parameters during a simulation run may or may not affect the simulation. For instance, if the Model Parameter is used to set the number of units of a Resource, changing the value of the Model Parameter will have no affect on the simulation since the units of a Resource are set at the beginning of a simulation run. However, changes to Model Parameters used to control entity flow or used for time durations will affect the simulation. If the Model Parameter is an Entity instance attribute, only Entities created after the change will reflect the change.

There is another option that does not appear on the properties dialog for global Entity Attributes. **Do Not Reset Before Each Replication** is a property of global Entity Type, Resource, Activity, and Model Attributes. If **Reset System** is selected on the **Run Settings** (page 90), all Attributes (other than Entity Attributes) are reset to their initial value. This does not happen if **Do Not Reset Before Each Replication** is selected. The Attribute maintains its current value.

Statistics Types refer to statistics collected for Attributes during a simulation run. These statistics are used in SIMPROCESS reports. Note that no statistics can be collected for Entity instance Attributes.

Observation Based and Time-Weighted refer to the way statistics are collected:

Observation Based tells SIMPROCESS to collect statistical data without considering the amount of time an Attribute maintains a particular level. Each time the value of an Attribute changes, the new value is added to a running total.

Time-Weighted provides time-weighted statistics. That is, the length of time an Attribute remains at a particular value is factored into the statistical data when the average value is calculated.

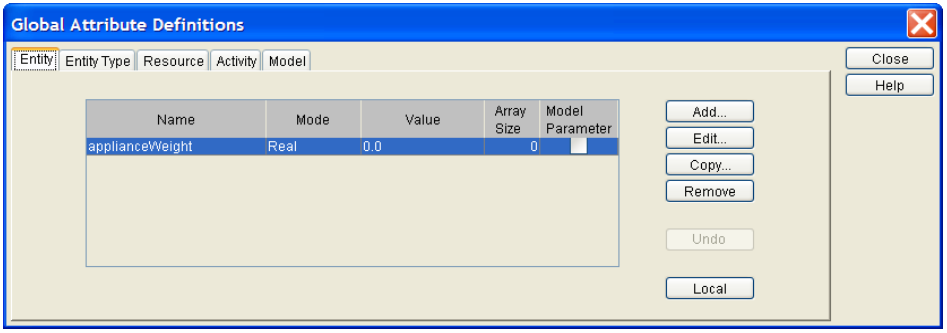
Real Time Histogram Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run (Real Time Plot) using a Histogram-type graphic. The plots can be saved, printed, resized, and re-read from prior saves using the menu on the Plot dialog.

Real Time Trace Plot tells SIMPROCESS to plot the Attribute value changes as they occur during the simulation run to a trace type graphic. The trace plots can be manipulated similar to the Histogram Plots.

Standard Report tells SIMPROCESS to write the statistics to the standard report file.

Click on **OK** to accept the options selected, or click on **Cancel** to exit without setting/resetting any

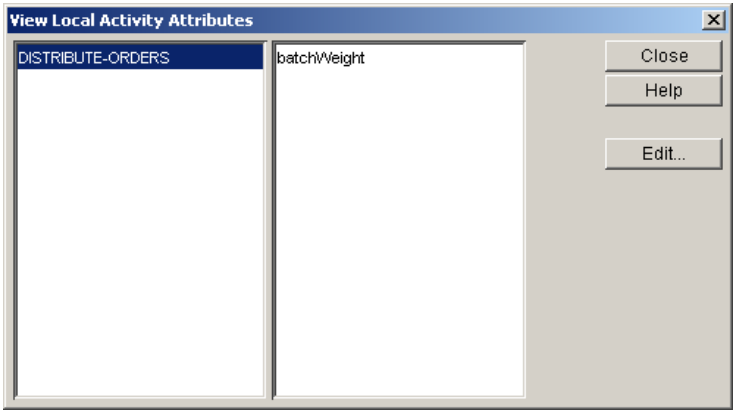
options.



An existing user Attribute can be copied by selecting the Attribute in the table and then clicking on the **Copy** button. The **User Attribute** dialog is displayed with the options and **Defaults** set to the values of the copied Attribute.

To remove an existing user Attribute, select the Attribute from the table, and then click on the **Remove** button. The **Undo** button will restore an Attribute definition that was removed.

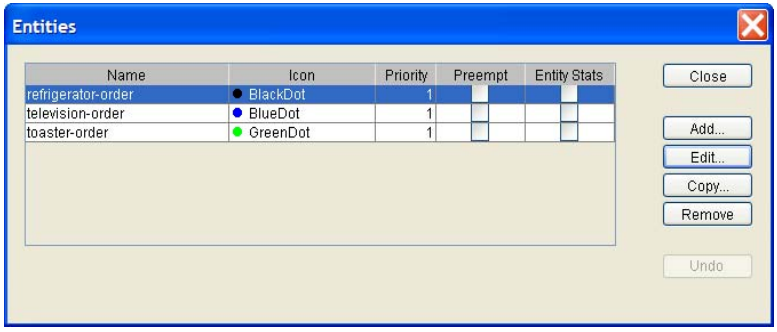
The **Local** button is on every tab except the **Model** tab. (Model Attributes are only global.) Selecting **Local** brings up a dialog that displays all model elements of the same type that have local Attributes. For example, the **Local** button on the **Activity** tab shows all Activities that have local Attributes defined. Selecting an item on the left displays the local Attributes for that item on the right. An item on the left can be edited by double clicking or by selecting the **Edit...** button. Note that from this dialog local Attributes cannot be defined for items that do not already have local Attributes.



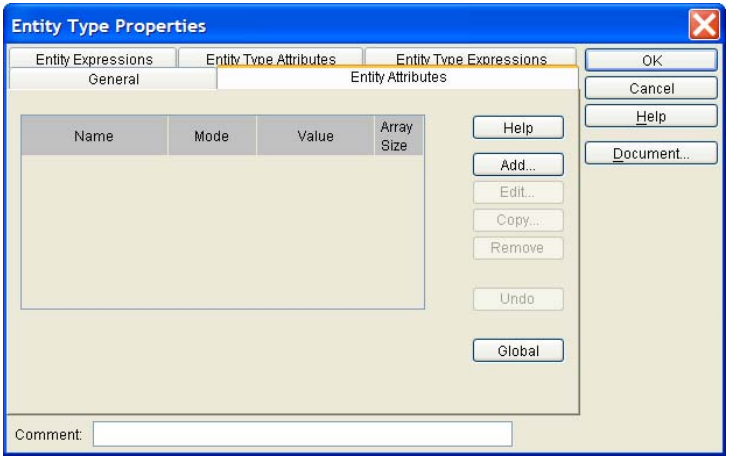
Click on **Close** when finished defining or modifying global Attributes.

Globally Defining Attributes from Dialogs

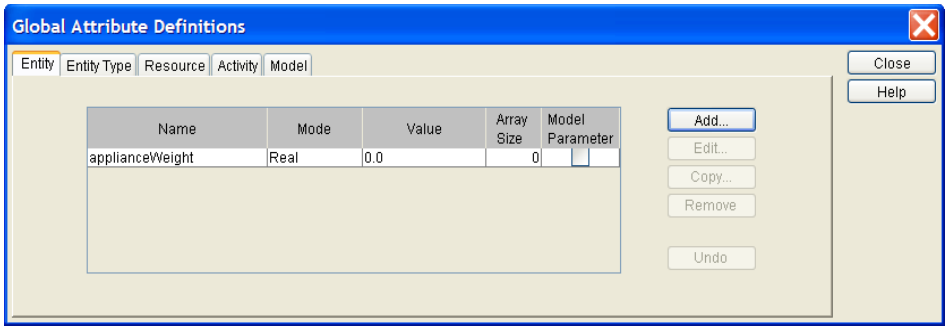
All global Attributes (other than Model Attributes) can also be accessed from the properties dialog of the appropriate model element (Entity, Resource, or Activity). For example, assume a model has three Entities defined (refrigerator-order, television-order, and toaster-order). Selecting **Entities...** from the **Define** menu, brings up the list of defined Entities.



Editing the refrigerator-order brings up the properties dialog. The image below shows the **Entity Attributes** tab selected.

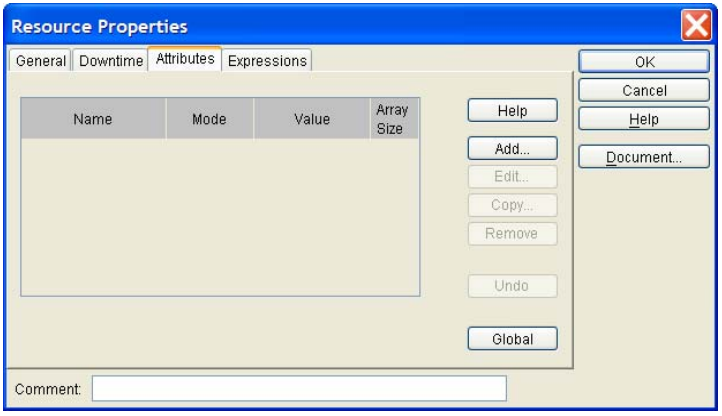


There are no local Entity Attributes defined for this Entity. The **Global** button brings up the Global Attribute Definitions dialog with the appropriate tab active. Since the **Entity Attribute** tab is selected on the Entity properties dialog, the **Entity** tab will be active on the Global Attribute Definitions dialog. Note that the **Local** button is missing since the Global Attribute Definitions dialog was opened from the properties dialog of a model element.



Defining a Local Attribute for a Model Element

A local Attribute is defined for a single model element (Entity, Resource, or Activity). Local Attributes are defined from the properties dialog of the model element. Note that Entity instance and Entity Type local Attributes are both defined from the Entity properties dialog (**Entity Attributes** and **Entity Type Attributes** tabs). The Resource and Activity properties dialog each have an **Attributes** tab. Attributes defined locally exist only for the model element in which they were defined. Local Attributes are managed in the same manner as the Global Attributes by using the **Add...**, **Edit...**, **Copy...**, and **Remove** buttons. The **Attributes** tab for Resource properties is shown below.

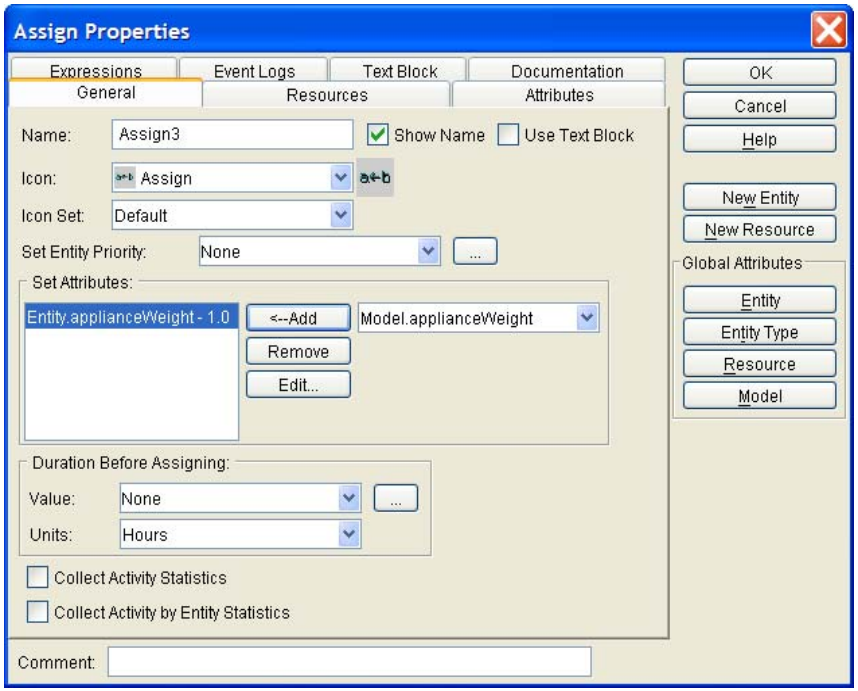


Assign Activity

The Assign Activity can be used to assign values to globally defined Attributes and local Entity instance and Entity Type Attributes. The Assign can also change the priority of an Entity.

Changing an Attribute Value with the Assign Activity

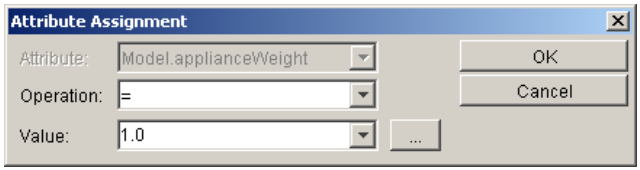
The **Set Attribute** list box of the Assign Activity is used to change the value of any global Attribute (except globally-defined Resource Attributes) and local Entity instance and Entity Type Attributes. Once an Attribute has been selected, clicking on the **Add** button will open up the **Assign Attribute Properties** dialog.



The combo box in the **Set Attributes** field contains the names of all the Attributes that the Assign Activity can access. Selecting an Attribute from the pull down list and then clicking on the **Add** button will open the **Attribute Assignment** dialog where the Attribute value is specified. Likewise, by selecting an Attribute from the left side of the **Set Attributes** list and clicking on the **Remove** or **Edit** buttons an Attribute assignment can be removed or changed.

The **Operation** field contains the operators that can be used to change the value of the selected Attribute. The supported operators are; =, +, -, *, and / (equals, addition, subtraction, multiplication, and division).

The **Value** field contains the value to be used with the **Operation**. This can take the form of a constant, a Statistical Distribution, a User-defined Function, or an Evaluate (Evl) Function. User-defined Functions can be found on page 257 of this chapter. The Evaluate Function is covered on page 235.

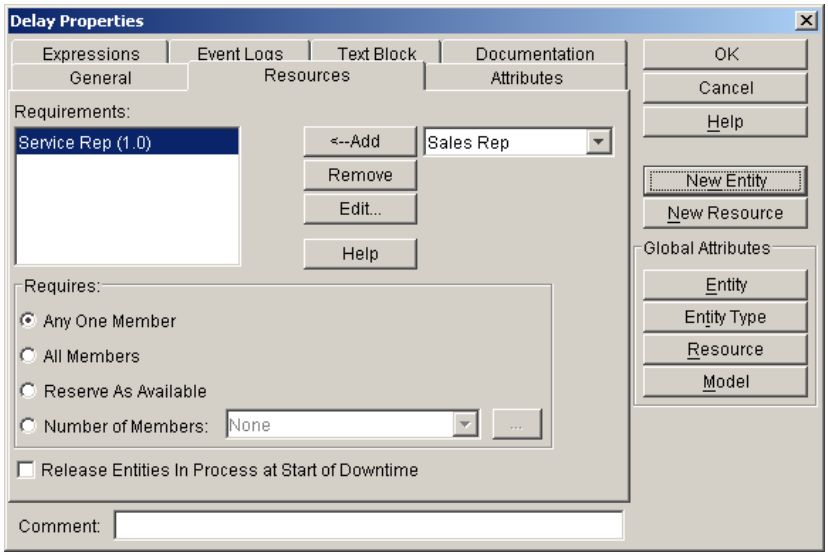


Each time an Entity enters the Assign Activity, the **Set Attribute** commands are performed.

Important: If the Attribute selected for assignment is a local Attribute, a run time error will occur if an Entity enters the Activity that does not have the selected Attribute defined.

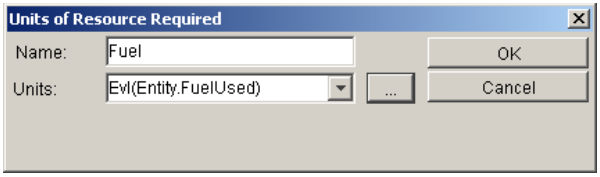
Variable Resource Usage

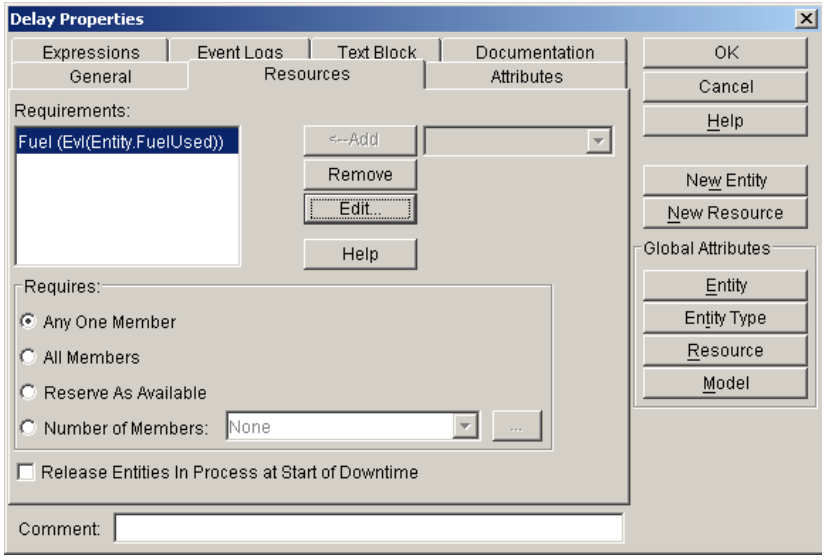
User-defined Attributes can be used to request units of Resources. Using an Attribute allows the units of Resource required by each Entity to vary. For instance, in the example from Chapter 5 (page 131) an Entity needed one unit of the Service Rep Resource for that Activity.



Thus, every Entity will get one and only one unit of the Resource. However, there may be instances where the amount of Resources needed would be different for each Entity. This is true many times when using consumable Resources (such as fuel). Any type of Attribute may be used to set these levels (Entity, Entity.Type, Resource, Activity, or Model). When Attributes are used, they must be provided in the Evl distribution function such as “Evl(Model.myattribute).” The Evl function gives added flexibility since mathematical functions can be used with the Attributes. “Evl(Model.myattribute + (Entity.myEntityattribute * SQRT(Activity.myActivityattribute))” is an example.

In addition to Attributes, any statistical distribution may be used. Use **Edit** to modify the existing requirement definition and then enter the Attribute that will have the unit information. The Attribute must be a real or integer type Attribute.





During the simulation run, if the units of Resource requested is larger than the Resource capacity, the Entity will not proceed since there will never be more units available than capacity. This will not occur when using consumable Resources. If the Resource is consumable, the Entity will continue when more Resource units are available. Also, if a fractional number of units is requested and fractional usage was not selected for the Resource, an error will occur.

Writing Expressions

The previous section discussed how to define user Attributes. This section discusses how to use them.

For Attributes to be useful, they must be able to be accessed and changed during a simulation run. SIMPROCESS provides opportunities to do this at many points during a simulation. The instructions written to process Attributes and SIMPROCESS model elements are called Expressions.

An Expression is a user-defined routine that runs within the larger SIMPROCESS program. In effect, SIMPROCESS checks at various points during a simulation run to see if there are any special instructions for it. If so, it runs the code. Expressions accomplish simulation and modeling requirements for which standard SIMPROCESS processing does not support.

The SIMPROCESS Expression language is introduced first, then how Expressions are implemented is explained.

SIMPROCESS Expression Language Basics

The SIMPROCESS Expression language contains the basic features of any programming language. Complex Expressions can be written in this language.

In the definitions that follow, the word *expression* with a lower case “e” refers to a mathematical expression. *Expression* with a capital “E” refers to the SIMPROCESS Expressions feature.

Types

SIMPROCESS supports a limited set of data types. The supported types are as follows:

- *BOOLEAN*

  A variable that contains the binary values of TRUE or FALSE

- *REAL*

  A variable that contains a real number

- *INTEGER*

  A variable that contains an integer number

- *STRING*

  A variable that contains an array of characters

Types are specified in either one of two ways: by declaring a variable local to the Expression such as the variables **`myReal`** and **`myString`**:

```
myReal : REAL;

myString : STRING;
```

or by selecting the Attribute type from the Attribute definition dialogs. The Attribute definition dialogs support the same types that can be declared locally in the Expression. However, the data type of Object is not supported in the Expressions. ANYOBJ is used instead of Object.

Operators

- *Assignment Operator*

  The assignment operator is used to assign a value to an Attribute:

  ```
  :=
  ```

  For example:

  ```
  x := 15;
  assignWeight := 1000;
  ```

  The colon (**:**) preceding the equal sign (**=**) is required. An error will occur if it is omitted.

  String values can be concatenated using the + operator:

  For example:

  ```
  mystring1:= "hello ";
  mystring2:= "dolly";
  mystring3:= mystring1 + mystring2;
  ```

  The string mystring3 now contains the value “hello dolly”. String concatenation can also be used on functions that return string values such as the SUBSTR function.

  For example:

  ```
  mystring1:= SUBSTR(0,5,mystring3) + " dude";
  ```

  The variable mystring1 will now contain “hello dude”.

- *Compare Operator*

  An equal sign without a preceding colon is used when comparing two values. Thus, the statement beginning:

  ```
  IF assignWeight = 1000...
  ```

compares the value of Attribute *assignWeight* to the number 1000.

- *Arithmetic Operators* used in the SIMPROCESS Expression language are **+** (addition), **-** (subtraction), ***** (multiplication), **/** (division), **DIV** (integer division), and **MOD** (modulus).
- *Relational Operators* include **=**, **<>** (not equal)**, <, <=, >, >=.**

Literals

- A *string* of printable characters on a single line is enclosed in quotation marks:

```
"The plain in Spain looks lovely in the rain.";
```

- A *boolean* literal is entered as uppercase TRUE or FALSE:

```
myBool := TRUE;
```

- An *integer* literal is entered as a whole number:

```
myInteger := 67;
```

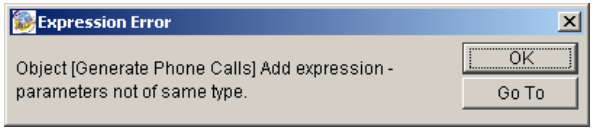
- A *real* literal is entered as a whole number plus a decimal, fraction, or whole number plus a fraction:

```
myReal1 := 67.;
myReal2 := 67.133;
myReal3 := 0.345;
```

Type Checking

- The use of variables (both those defined locally in the Expression and those defined as Attributes) in Expressions will be checked for correct type on assignment statements. For example, the following code will produce a type mismatch by the Expression interpreter.

```
myReal : REAL;
myString : STRING;
myString := "Hello Dolly";
myReal := myReal + myString;
```



System Methods

- System methods are commands which result in a system action or return a value from the underlying system. One commonly-used function is **SimTime**, which returns a Real number containing the current simulation time.
- For a list of System Methods available in SIMPROCESS, refer to page 465.

Expression Language Statements:

- **IF condition**
  {ELSIF condition}
  {ELSE condition}
  END IF;
- **WHILE condition**
  END WHILE;
- **FOR expression TO|DOWNTO expression [BY expression]**
  END FOR;
- **RETURN (possible return value)**
- **EXIT (with WHILE or FOR loops)**
- **OUTPUT**

SIMPROCESS Expression language syntax:

1. The SIMPROCESS Expression language is case sensitive. An Attribute named **Applianceweight** is not the same Attribute as the Attribute referred to as **applianceWeight**.
2. All built-in language elements are in capital letters (**IF**, **END,WHILE**, etc.).
3. Each Expression language statement ends with a semicolon (**;**). The exceptions to this are lines that begin with **IF**, **ELSIF**, **ELSE**, **WHILE**, and **FOR**;
4. Comments can be included in Expressions by enclosing them in curly brackets (**{ }**). For example:

   {This is a comment}

   Do not end a comment line with a semicolon.

5. Basic conditional logic has the form:

```
IF a < b
 x := c;
ELSIF a < c
 x := d;
END IF;
```

For example:

```
IF batchweight > 2000
  MaxBatchSize := 100;
  batchWeight := 0;
ELSIF batchweight > 1800
  MaxBatchSize := 110;
END IF;
```

Messages can be displayed in the SIMPROCESS Expression Output Dialog with the **OUTPUT** statement. This is useful for tracking the value of Attributes as a simulation proceeds. The **OUTPUT** statement has the form:

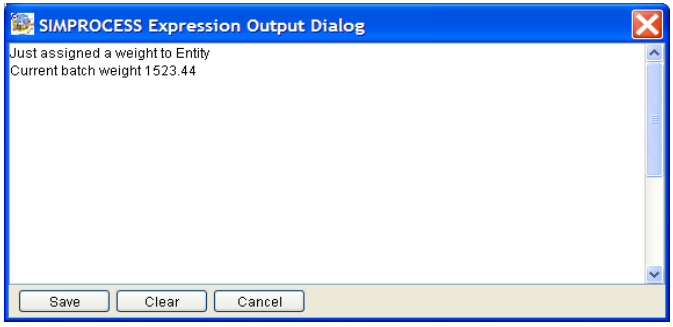
```
OUTPUT(expression);
```

For example:

```
OUTPUT("Just assigned a weight to Entity");

OUTPUT("Current batch weight ",  batchWeight);
```

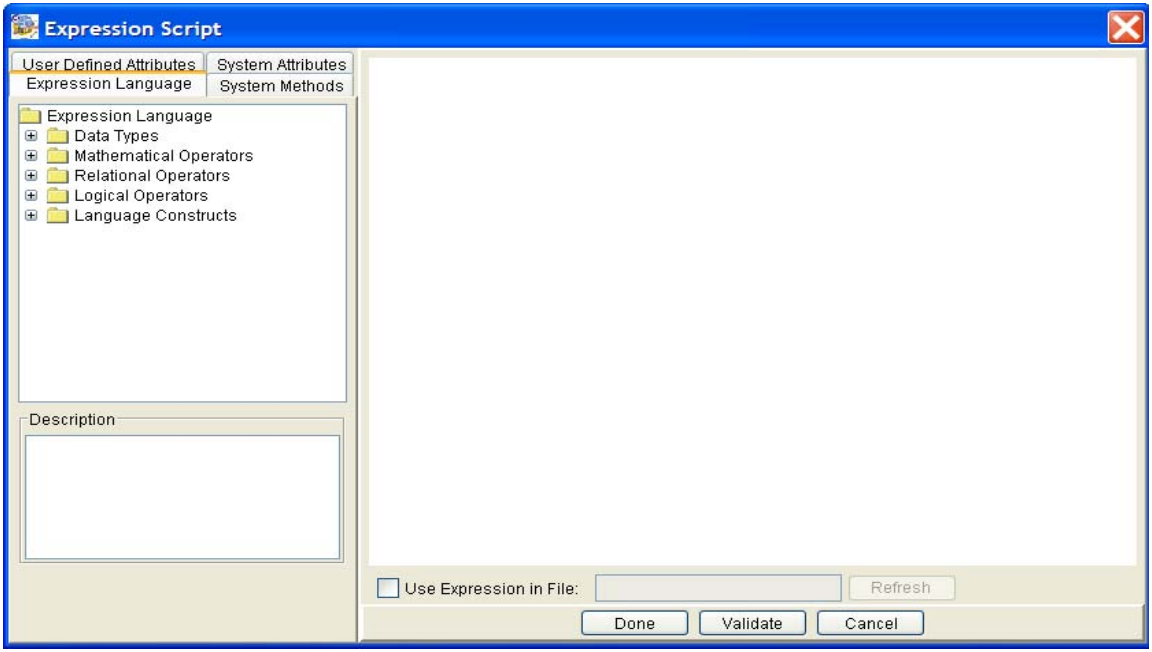
In the second example, the value of Attribute **batchWeight** is displayed following the text "Current batch weight ". The literal string and Attribute name are separated by a comma so the actual **batchWeight** value will appear next to the string.



Expression Editor

Editing any Expression activation event brings up the Expression Editor. On the right is the text area for typing in the Expression. Cut, copy, and paste can be used in the text area by using the appropriate keyboard equivalents. On the left are four tabs (**Expression Language**, **System Methods**, **System Attributes**, and **User Defined Attributes**) that list the items that can be included in the Expression. The **Expression Language** tab lists data types, operators, and constructs of the SIMPROCESS Expression Language along with a description of the selected item. The **System Methods** tab lists the System Methods available for SIMPROCESS along with the **Arguments**, the type the system method **Returns**, and **Description** of the selected item. The **System Attributes** tab lists the system Attributes defined for each simulation object in SIMPROCESS. Included is the **Get/Set** property of the system Attribute, the **Type** of the system Attribute (INTEGER, REAL, etc.), and a **Description** of the selected item. (See "SIMPROCESS System Attributes and Methods," beginning on page 458 for more information on System Attributes and System Methods.) The **User Defined Attributes** tab lists all the global Attributes defined in the model and any local Attributes defined for the Expression owner including the **Type** of the selected Attribute. Double clicking an item on any of the lists causes the item to appear in the Expression text area.

The **Validate** button underneath the text area checks the syntax of the Expression without closing the editor. The **Done** button checks the syntax of the Expression and, if there are no errors, closes the Expression editor.



Expressions entered into the Expression editor are saved as a part of the model file. This is the preferred method of storing Expressions since copies made of the model file (either external to SIMPROCESS or with **Save As**) will automatically have any Expressions that were defined in the original model file, all the capabilities of the Expression Search feature (page 30) are available, and templates defined (page 199) will also have any Expressions included in the original item being templated. However, Expressions can also be stored in external files. This can be useful if the same Expression is used multiple places, or if there is a need to change an Expression without opening the model. The same Expression file can be used with multiple models, but this is discouraged since it is best if the Expression file is stored in the model's directory. Storing an Expression file in the model's directory shows clear linkage between an Expression file and a model. An Expression file must be an ASCII file. If a word processor is used to create the file, make sure the file is saved in text format. Note that when using Expression Search, if the **Search For** field is empty, the Expression Search will find any item that has an Expression whether stored in the model or stored in a file, but searches for specific text ignore Expressions in files.

To use an external file for an Expression select the **Use Expression in File** checkbox, and enter a file name in the adjoining text field. If the file name does not have a path included, the file is assumed to be in the model's directory. If a path is included, it must be a complete path. SIMPROCESS will not create the file entered in the text field. The file must be created by an editor independent of SIMPROCESS. When there is already a file assigned, the text of the Expression file is loaded into the Expression editor when the editor opens. If the file is assigned after the editor opens, the **Refresh** button can be used to load the Expression. Expressions from files are not editable in the Expression editor. The text of an Expression in a file is loaded into the Expression editor so the syntax of the Expression can be checked using the **Validate** button. Expressions edited in another editor should always have the syntax checked before running the simulation. If the syntax error is caught at run time the simulation will stop. If the **Validate** button shows there are errors, the Expression can be modified in another editor, the file re-saved, and then the Expression reloaded using the **Refresh** button. Clicking the **Done** button checks the syntax before closing the Expression editor. However, unlike when the expression is stored in the model, the option to close with errors is available.

If the **Use Expression in File** checkbox is deselected, the text of the Expression becomes editable. However, if the editor is closed with **Use Expression in File** deselected, the Expression becomes a part of the model. If **Use Expression in File** is reselected before closing the editor, any changes made are lost since Expressions are only read from the specified file. Changes to the Expression must be done and saved to the file in another editor. Expressions can be copied from the SIMPROCESS Expression editor and pasted into another editor by highlighting the desired text and using the keyboard equivalents of **Copy** and **Paste**.

Using Attributes in Expressions

The value of an Attribute may be useful in the calculation of an Expression for a different construct than that for which the Attribute was defined. For instance, the duration of a Delay Activity could take

the value of an Attribute of the Entity currently at the Delay Activity. To do so, the Expression on the Activity must access the value of the Attribute on the Entity. This is accomplished by referring to the Entity Attribute with the prefix "`Entity`." followed by the name of the Entity Attribute.

Using the duration example above, for an Entity Attribute called "**`TimeFactor`**", the duration that each Entity (that carries the **`TimeFactor`** Attribute) will spend at a Delay Activity can be set with the following statement:

```
NextDelay := Entity.TimeFactor;
```

By placing the above statement in the "`Accept Entity`" activation event (for a listing of activation events, see "Expression Activation Events," beginning on page 236) on the **Delay Activity**, the value of the system Attribute, **`NextDelay`**, will take the value of the **`TimeFactor`** Attribute. The result is, for each instance of an Entity reaching this Activity, its processing time at that Activity is determined by the value of the Entity Attribute, **`TimeFactor`**, that each instance of the Entity carries. However, this assumes that there is no wait for Resources. If an Entity has to wait, another Entity could enter and change **`NextDelay`** before the first Entity is able to process. The preferred method is to use the **Evaluate** function in the **Duration Value** field on the **Delay Activity** to return the value of the Attribute **`TimeFactor`**. This method is better, since the duration of each Entity at the **Delay Activity** is calculated from the **`TimeFactor`** Attribute. This is visible on the **Properties** dialog of the Delay rather than in an Expression. Also, there is no possibility of another Entity changing the value of the delay. See the "Evaluate (Evl) Function" on page 235 for more detail.

The format would be similar for an Entity Type Attribute. If the Attribute to be referenced was named "**`TypeTime`**", it would be used in the Expression of a construct other than an Entity as:

```
Entity.Type.TypeTime
```

The same holds true for Attributes of other SIMPROCESS constructs as well. An Activity Attribute called "**`ActivAttr`**" that is referenced in an Expression on a construct other than an Activity, would be referred to as:

```
Activity.ActivAttr
```

A Model Attribute called **`ModAttr`** would be referred to as:

```
Model.ModAttr
```

User-defined Resource Attributes can be accessed by an Expression from any other construct in SIMPROCESS, and values can be assigned to those Attributes by using the syntax described above. However, User-defined and System Attributes for Resources must be accessed by using the **`Resource`** System Method.

For instance, to reference the number of units currently busy of the Resource called **`Resource1`**, use:

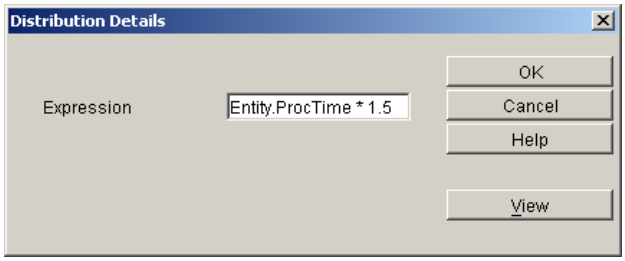
```
Resource("Resource1").UnitsBusy
```

These are just some basics of the SIMPROCESS Expression language. See “System Method Examples” on page 480 for more detail.

Evaluate (Evl) Function

The simplest use of an Expression is with the Evaluate (Evl) function. This function supports a single line Expression. That Expression can contain any of the System Methods, System Attributes, User-defined Attributes and Operators that are supported at the Activation Events level described in the next section. The Evl function can be found on any of the combo boxes where the standard distributions and User-defined Functions are listed.

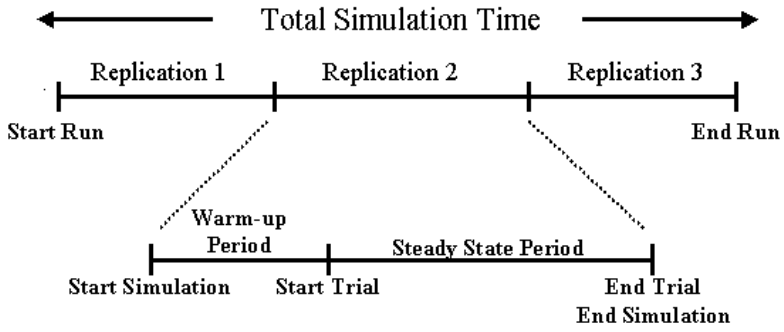
An example using the Evaluate function is a system with a processing time (Delay) that is a function of an Entity Attribute. Select the **`Evl(1.0)`** function on the **Hours** field from the Delay Activity's **Properties** dialog. Clicking the **Detail** button will open an **Evaluate** dialog where the Expression describing the processing time is entered. This example reads the Entity's processing time (given by the Entity Attribute **`ProcTime`**) and multiplies it by 1.5. This value would then be the delay time for the Activity.



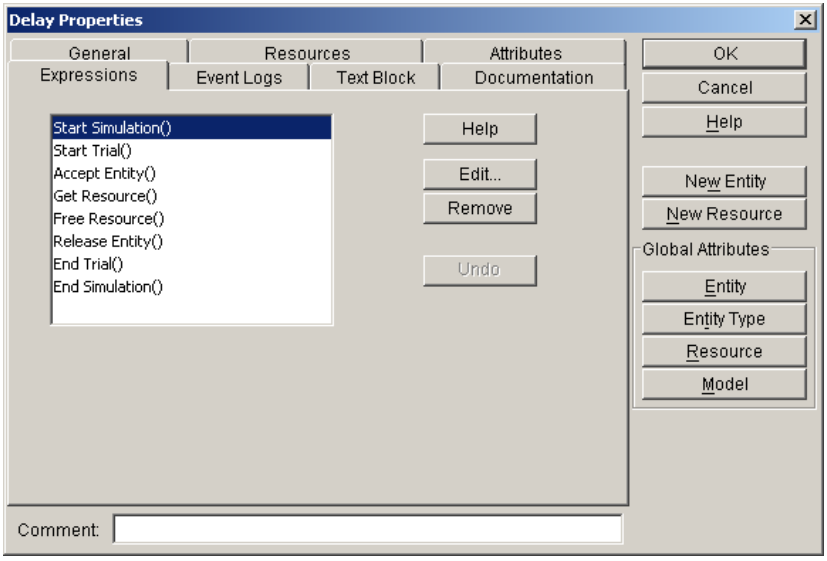
Expression Activation Events

SIMPROCESS has a set of activation points at which it checks for the existence of Expressions, and then runs those that it finds. An Expression is assigned to an activation point at the time it is defined.

Each activation point corresponds to a simulation event and has a name identifying it to SIMPROCESS. For example, the start of a replication is referred to as the **`Start Simulation`** event. The **`Start Trial`** event marks the beginning of a single trial within a replication (after warmup).

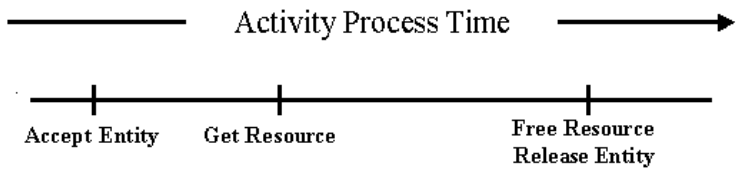


Some events can occur many times during a simulation. The **`Start Trial`** and **`End Trial`** events occur once during each replication of a multi-replication simulation. If the simulation contains only a single replication, these events occur just once. The **`Start Simulation`** and **`End Simulation`** events occur once during each replication of a multi-replication simulation if **Reset System** is selected in the **Simulation Run Setting** dialog. Otherwise, the **`Start Simulation`** event occurs just once at the beginning of the first replication. The **`End Simulation`** event occurs at the end of the last replication. These are specified on the **Expressions** tab of Process, Activity, Resource, and Entity Type dialogs.



`Start Run` and **`End Run`** are model Expressions only (menu **Define/Model Expressions**). These Expressions are executed only once no matter how many replications are run. **`Start Run`** is the very first Expression executed, and **`End Run`** is the very last Expression executed. These Expressions are particularly useful for opening and closing files that are needed throughout the simulation. (See "Methods OpenFile, CloseFile, ReadFromFile, and WriteToFile:," beginning on page 484 for information on opening and closing files.) The **`Start Simulation`** and **`Start Trial`** model Expressions are executed before the **`Start Simulation`** and **`Start Trial`** Expressions of Entity Types, Resources, Activities, and Processes. The **`End Simulation`** and **`End Trial`** model Expressions are executed after the **`End Simulation`** and **`End Trial`** Expressions of Entity Types, Resources, Activities, and Processes.

Events related to Entities and Resources can occur numerous times throughout a simulation trial. For example, an Entity's arrival at an Activity is a simulation event called **`Accept Entity`** (so-called because the Entity is being accepted into the Activity). This can occur thousands of times during a long simulation, once for each Entity that arrives at the Activity.



Every Expression is associated with a specific SIMPROCESS model element. Select the model element that requires customized processing, specify the event at which the processing is to occur, and then write the Expression to do the processing. "Example: Batching Entities Based on Weight" on page 242, describes this Process in detail.

Not every event is available as an activation point for every model element. For example, the initial value of an Attribute for an Entity can be set when the Entity is first generated (**`Initialize Entity`**), or when the Entity is released from a Generate Activity (**`Release Entity`**). But the value of an Entity Attribute cannot be set when the simulation first begins to run (**`Start Simulation`**), because no Entities have been generated at that point.

The table below contains a complete list of activation events. Note that the order of the elements is the order in which the Expressions are executed.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Start Run	The beginning of a simulation run. Occurs only once, no matter how many replications.	Model.
Start Simulation	The beginning of the first replication, before the warm-up period (if any). If **`Reset System`** is selected, it occurs at the beginning of each replication.	Model. Entity Types. Resources. All Activities.
Start Trial	Beginning of a trial within the simulation, after the warm-up period (if any).	Model. Resources. Entity Types. All Activities.
Initialize Entity	Creation (allocation) of an Entity. This typically occurs in a Generate Activity, but may also occur in the Batch, Transform, Copy, Split, and Assemble Activities.	Entity Instances. Entity Types.
Accept Entity	Arrival of an Entity at an Activity or Process.	Processes plus all Activities except Generate. Entity Instances.
Get Resource	Obtainment of a Resource by an Activity.	Resources. All Activities except Generate, Free Resource, & Dispose.
Interrupt Processing	Entity processing is interrupted by a higher priority Entity or by a Resource going down.	Entity Instances.
Resume Processing	Entity processing is resumed after interruption.	Entity Instances.
Free Resource	Release of a Resource by an Activity.	Resources. All Activities except Generate, Get Resource, & Dispose.

Event Name	Activation Point (and Comments)	Model Elements Active For:
Release Entity	Release of an Entity from an Activity or Process.	Processes plus all Activities except Dispose. Entity Instances.
Dispose of Entity	Dispose of an Entity.	Entity Instances. Entity Types.
End Trial	End of a simulation trial.	Model. Entity Types. Resources. All Activities.
End Simulation	The end of a simulation replication. Statistic collection for the replication ends at this point.	Model. Entity Types. Resources. All Activities.
End Run	The end of a simulation run. Occurs only once at the end of all replications.	Model.

Attribute Value Initialization

User-defined Attributes can be initialized at several places in a SIMPROCESS model. The following procedure shows how SIMPROCESS sets Attribute values along the simulation timeline.

When the simulation is started, SIMPROCESS will:

1. Initialize Attributes to the values that are specified in the **Attribute Definition** dialog
2. Execute the reset system mechanism if the **Reset System** option is selected and **Do Not Reset Before Each Replication** is not selected (reset Attribute to the values specified in the **Attribute Definition** dialog)
3. Execute any Start Simulation Expressions (Attributes can be set to different values in these Expressions).

After a replication is complete, SIMPROCESS may reset Attribute values for the next replication. If the **Reset System** option is selected in **Run Settings**, SIMPROCESS will continue on the next replication starting from item 2, as listed above. Otherwise, it will start from item 3.

Example: Batching Entities Based on Weight

This example describes a method of releasing Entities based on weight, an Attribute that SIMPROCESS is not inherently aware of. The model depicts the product distribution Process of an appliance manufacturer. Here is a simplified view of the model:

1. Appliance orders are received from customers.

   This is the Generate Activity. Each appliance order is an Entity.

2. The orders are processed and eventually make their way to a distribution center in the form of appliances.

   This takes place within a subprocess. The details are not important for this example.

3. Appliances are shipped to customers from the distribution center. A Batch Activity is used to ship appliances as a group.

   Shipments are released when the total weight of all appliances awaiting delivery reaches 5000 pounds.

In order to accomplish the objective of releasing the batch when a certain weight is accumulated, do the following:

1. Define Attributes to represent the weight Attribute of Entities (define global Entity Attribute **`applianceWeight`**).
2. Assign values to the weight Attributes.
3. Accumulate and track the weight of Entities received at the Batch Activity (define local Attribute at Batch Activity named **`batchWeight`**).
4. Trigger the release of Entities if a specified weight is reached, and prevent the release of Entities otherwise.

Build Process Flow

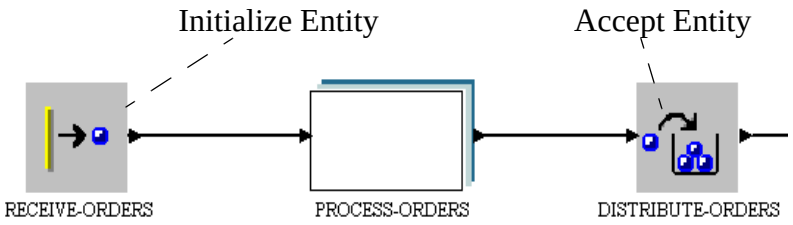
Open a new model and place a Generate Activity, Process, Batch Activity, and Dispose activity on the layout. Connect the Activities. Descend into the Process and connect the incoming Input Pad to the outgoing Output Pad. The details of the Process are not important for this example.

Initializing Entity Attributes

First, assign a value to the *applianceWeight* of each Entity generated during a simulation. This can be done as soon as the Entity is created. Then, when the Entity reaches the Batch Activity, add its weight to a running total and compare this total to the maximum allowable weight. The points in the simulation where Expressions need to be activated are:

- Entity initialization
- Receipt of the Entity by an Activity.

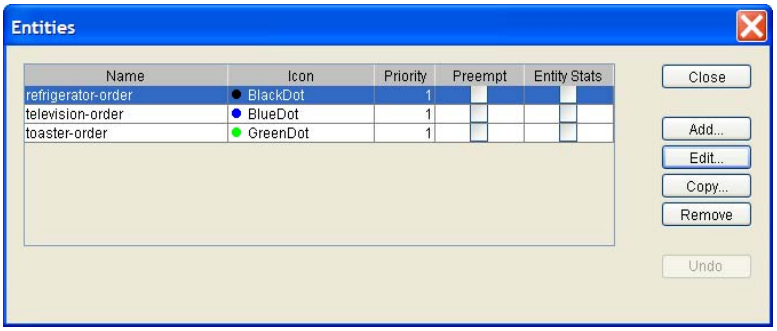
Entities are initialized by SIMPROCESS at the **`Initialize Entity`** event. Entities are received by an Activity at the **`Accept Entity`** event.



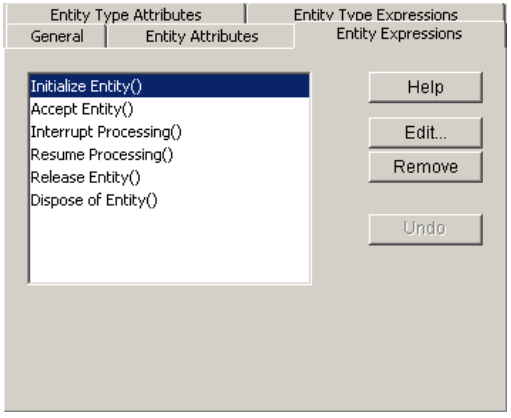
Defining the Expression at Entity Initialization

To assign an initial value to an Entity's **`applianceWeight`**, define an Expression for each type of Entity in the model. The Expression is a single assignment statement (e.g., **`applianceWeight := 1000.0`**) to be executed when the Entity is first generated (the **`Initialize Entity`** event):

1. From the **Define** pull-down menu, select **Entities**.



2. This model contains three Entity types. An Expression must be defined for each Entity. Start by selecting the first Entity on the list, and then press **Edit**.
3. Every refrigerator-order Entity that is generated needs to be initialized, so select the **Entity Expressions** tab.



4. Six simulation events are listed on the **Entity Expressions** tab. These are the points during the simulation at which SIMPROCESS checks for Expressions which apply to Entity instances.

   The event needed is **`Initialize Entity`**, which is the point at which an Entity is first generated (initialized). Highlight **`Initialize Entity`** and click on **Edit**.
5. SIMPROCESS invokes the Expression editor and opens an Expression script dialog. Add just one line to the text dialog:

   ```
   applianceWeight := 1000.0;
   ```

   This assigns a value of 1000.0 to **`applianceWeight`**.

6. Close the editor.
7. Follow the same procedure for each of the Entities in the model, but assign them different weights. Assign a weight of 100.0 to *television-order* and 10.0 to *toaster-order.*
8. Click **OK** when finished.

Defining the Expression When an Entity Is Released

The method described above works fine to initialize the **applianceWeight** Attribute of Entities. It's fairly simple, too; it requires only a single statement in each Expression. But it is redundant in that Expressions must be defined for each type of Entity. Defining an Expression for each Entity would be tedious and time consuming if there are many different types of Entities.

There are other options. A weight does not have to be assigned to the Entities as soon as they are created. All that is required is the weight be assigned before the Entity reaches the Batch Activity where appliances are distributed (DISTRIBUTE-ORDERS).

In this model, all Entities are generated by a single Generate Activity. So an Expression can be defined in the Generate Activity that activates whenever an Entity is released (**Release Entity** event). This is the most efficient way to proceed. One Expression handles the initialization of any Entity's **applianceWeight**.

1. Double-click on the Generate (RECEIVE-ORDERS) Activity.
2. In the **Generate Activity Properties** dialog, click on the **Expressions** tab. Five simulation events are listed. The first, **Start Simulation,** will occur before any Entities are generated. **Start Trial** will occur before any Entities are generated if there is no warmup period; otherwise, some Entities could be generated if Entity generation was scheduled during the warmup period. **Release Entity** serves the purpose, so highlight it and click on **Edit**.
3. Enter the following lines in the Expression dialog:

```
IF Entity.Name = "refrigerator-order"
   Entity.applianceWeight := 5000.0;
ELSIF Entity.Name = "television-order"
   Entity.applianceWeight := 100.0;
ELSE
   Entity.applianceWeight := 10.0;
END IF;
```

   These instructions check the name of the Entity being released at the Activity. The name identifies the type of Entity. A value is assigned to **applianceWeight** based on the Entity type.

4. Close the editor.

5. Click on **Close**, and then **OK**.

Releasing Entities Based on Weight

Two more Expressions are needed to complete the model. In the first Expression, check the weight of the Entities received at the batch Activity and trigger their release if the weight reaches a certain number:

1. Double-click on the DISTRIBUTE-ORDERS Activity.
2. In the **Batch Activity Properties** dialog, click on the **Expressions** tab.
3. There are eight activation events listed on the **Expressions** tab for a Batch Activity. **`Accept Entity`** occurs when an Entity arrives at the Activity, so highlight this event and click on **Edit**.
4. Insert the following code:

```
batchWeight : REAL;
batchWeight := batchWeight + Entity.applianceWeight;
IF batchWeight >= 5000.0
   MaxBatchSize := NumberIn;
   OUTPUT("Batch weight is ",
      batchWeight);
      batchWeight := 0.0;
END IF;
```

   In this Expression, the weight of the just-received Entity is added to the total weight of all Entities received. If the total weight exceeds 5000.0, a batch release is triggered by resetting **`MaxBatchSize`**, the Attribute that sets the maximum number of Entities that can be held in the batch. With the Activity about to be emptied of Entities, the **`batchWeight`** Attribute is reset to zero.

   The **`OUTPUT`** statement in the Expression is there as an example of displaying information in the message dialog. It is not needed by the model. **`OUTPUT`** statements can be interspersed in Expressions in order to trace events during a simulation. Displaying the value of **`batchWeight`**, for instance, verifies that the batch is really released when the weight exceeds 5000.0.
5. Close the editor.

There is one more thing this model needs. The maximum batch size must be reset again after the Entities are released. Entities should not be released when the DISTRIBUTE-ORDER batch reaches a certain number. Only accumulating 5000 pounds of weight should trigger release.

As it stands now, **`MaxBatchSize`** is set to the size of the previous batch accumulated at the Activity.

This was done to force a release of Entities when **batchWeight** reached 5000 pounds. The number of Entities could reach the current **MaxBatchSize** again before accumulating 5000 pounds of weight. To prevent that, reset this Attribute to a number that can not possibly be reached before accumulating 5000 pounds of weight:

1. In the **Expressions** tab, select **Release Entity.** This is the event where the Entities are released from the batch Activity.

   Press **Edit.**

2. Enter the following statement:

```
MaxBatchSize := 100000;
```

3. Close the editor.

The model should now be ready to run.

An Alternative Method Using Entity Types

This example works fine, but there are alternative approaches (as there often are when building models in SIMPROCESS).

A couple of alternatives have already been described for initializing the value of the **applianceWeight** Attribute ("Defining the Expression at Entity Initialization" on page 243 versus "Defining the Expression When an Entity Is Released" on page 245). Another alternative involves defining the **applianceWeight** Attribute for Entity types instead of Entity instances.

In this example, a weight Attribute was defined for every Entity instance in the model. Every refrigerator order was assigned a weight of 5000, every television order, 100, etc. The assigned weights remained unchanged during the course of the simulation.

Another approach would be to define an **applianceWeight** Attribute for each Entity type and initialize it at the **Start Simulation** event. Then, in the Expression defined at **Accept Entity** for the DISTRIBUTE-ORDERS Activity, the Entity's weight would be referenced as:

```
Entity.Type.applianceWeight
```

This would work fine for this example. But suppose that the weight of an order could be affected by some step in the Process being modeled and this needed to be reflected in the model. For example, a customer order could include accessories for an appliance (e.g., cables and remote control for a television), adding to the weight of the order. In that case, attaching the **applianceWeight** Attribute to each Entity instance allows the weight of each television order to vary, which cannot be done if the Attribute belongs to the Entity's type.

Using Object Attributes in Expressions

The code in this example uses an Expression language construct referred to as a *qualified reference*. For instance:

```
Entity.Name
```

refers to an object, named **Entity**, and an Attribute, **Name**.

An *object* Attribute leads SIMPROCESS to the model element containing the Attributes of interest. Unlike other Attributes, the value of the object is not of interest, only the values of its system or user Attributes.

In step 3, the type of Entity being released by the Generate Activity was identified. The System Attribute **Name** identifies the Entity type. But a **Name** Attribute also identifies Resources and Activities. So referring to **Name** alone is ambiguous. In fact, SIMPROCESS assumes the reference is to the model element that called the Expression (the **RECEIVE-ORDERS** Activity). To avoid confusion in the Expression, always qualify Attributes with the object name such as (Entity.Name, Self.Name, Activity.Name, Self.myattribute, etc.).

That is where object Attributes come in. They identify the model element of interest.

- The **Entity** object Attribute tells SIMPROCESS to look at the Entity being processed in the current Activity.
- An Attribute called **Self** points at the current model element; that is, the model element the Expression has been invoked from.

So **Entity.Name** returns the type name of the Entity instance being processed at the **RECEIVE-ORDERS** Activity, while **Self.Name** returns the name "**RECEIVE-ORDERS**."

A qualified reference is also employed to set the User Defined Attribute **applianceWeight:**

```
Entity.applianceWeight := 5000.0;
```

Now, **applianceWeight** was specifically defined as an Attribute of Entities. However, this does not mean that any reference to this Attribute would be unmistakable, that it can only refer to one thing.

But in fact, the reference to **applianceWeight** must be qualified by an object reference. This is because without specifying a qualifier, SIMPROCESS assumes the reference is to an Attribute of the current model element. In this case, the current model element is the Generate Activity, **RECEIVE-ORDERS**, since it is the model element which invoked the Expression. There is no Attribute named **applianceWeight** associated with this Activity, and an unqualified reference to **applianceWeight** would result in an error.

Note that an unqualified reference to the Attribute **Name** refers to the name of the current model element,

RECEIVE-ORDERS. If that is the Attribute of interest, the Attribute does not have to be qualified.

Object references can be stacked to gain access to variables that may not be within the scope of the current object but may still be of interest in an Expression. For example, the following Expression snippets are valid uses of object references from within an Activity Expression under the Accept Entity event.

```
OUTPUT("In ",Self.Name, " Entity = ", Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity  }

OUTPUT("In ",Self.Name, " Entity Type = ", Entity.Type.Name);

{ produces the name of the Activity and the name of the current
   Entity's type  }

OUTPUT("In ",Self.Activity.Name, " Entity = ",
   Activity.Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity  }
```

Notice in the third OUTPUT example, the object reference to the current Activity is stacked. In other words, the Object Self points to itself, and the Activity object also points to the current Activity. This is basically a circular reference and does not really do anything other than slow down the simulation and confuse anyone that may read the Expression (something like Activity.Activity.Activity.Entity.Name could also have been used which is the same result but is even more confusing). The Expression language allows this feature so that access can be gained to certain objects when appropriate. Consider the following example from within a Resource Expression under the Get Resource event:

```
OUTPUT("In ",Self.Name, " Activity.Entity.Name  = ",
   Activity.Entity.Name);

{ produces the name of the Activity and the name of the current
   Entity in that Activity  }
```

The above statement gains access to the Entity in the Activity that is assigning the Resource. When using the stacked object references, pay close attention to what is the current state of the model. Consider the following example for an Entity Expression under **Initialize Entity** event.

```
OUTPUT("In ",Self.Name, " Activity = ", Activity.Name);

{ produces an error  }
```

The above OUTPUT statement produces an error since there is no Activity object in scope at the time an Entity is initialized. An Entity must be accepted into an Activity before the above statement would work. This is a good example of being aware of the state of the simulation when referencing objects. Other common mistakes are using the Resource object references (for example, Resource("myResource").Activity.Name from within an Activity Expression before the Get Resource event has occurred) or Sibling and Child references without considering the state of the Siblings and Children (for example, Sibling("Delay6").Entity.Name may produce an error if there is no Entity current in the Delay6 Activity).

Object references are very powerful but can be confusing. It is recommended that the simplest form possible of object reference be used in Expressions and that objects be accessed from the most obvious point of scope (i.e., placing the Expressions behind the appropriate events).

The use of object reference also applies to the Child, Parent, and Sibling references. Any number of object references can be stacked and return appropriate results unless a Child or Sibling is referenced that does not exist, or a Parent is referenced from the top-level diagram - all of which will return an error and terminate the simulation. The following example would work in a Process Expression as long as it was invoked from a Process that is at least three levels deep, has a Sibling named "Delay6", and a Child named "Delay7":

```
OUTPUT("In ",SelfName, " Sibling = ", Sibling("Delay6").Name,
   Child("Delay7").Name), " two parents up = ",
   Self.Parent.Parent.Name;

{ produces the name of the Activity, the name of Delay6, the name
   of Delay7, and the name of the parent's parent of the current
   Process  }
```

There are certain cases where it may be necessary to use object references as variables to gain further control over what Attributes can be accessed or to provide some flexibility in an Expression. There are basically two ways to use object references in variables: define local script variables of type ANYOBJ, or define SIMPROCESS user-defined variables of type Object. Note that both of these applications allow the variable to be setup as an array (just like any other variable type). Consider the following examples:

```
{ this expression is placed in the Accept Entity event of an Activity
   that has two local attributes defined - Attribute1 is a String
   and Attribute2 is of type Object }

myobj : ANYOBJ;

myobjarray[5] : ANYOBJ;

myobj:=Self;
```

```
{ points to the Activity the script is in  }

myobjarray[0]:=Activity.Entity;

{ points to the current Entity in the Activity }

myobjarray[1]:= Sibling("Delay6");

{ points to a sibling Activity called Delay6 }

myobjarray[2]:= Resource("myResource");

{ points to a Resource defined in the model }

Self.Attribute1:="hello dolly";

Self.Attribute2:=myobjarray[0];

{ points to the Activity.Entity object assigned to cell 0 of
   myobjarray above }

Self.Attribute2:=myobjarray[1];

{ now points to the sibling Delay6 assiged above}

myobj.Attribute1:="hey mister";

{ replaces the value in attribute1 with the new string "hey mister"
   since myobj also points to self - see above }

myobjarray[4]:=myobj.Entity.Type;

{points to the Entity type of the current Entity in the current
   Activity }

myobjarry[5]:= myobj;

{ produces an error since myobjarray has only cells 0 - 4 defined
   -  the subscript is out of bounds ]
```

Type checking is done on the assignment of variables where possible. This is to prohibit assigning basic type (REAL, INTEGER, STRING, etc.) variables to Object-type variables. Likewise, it precludes assigning object references to basic types. The following lines in the same script above would produce errors, and the simulation would terminate.

```
myobj := "hello dolly";
```

```
{produces an error because myobj is of type ANYOBJ and "hello dolly"
   is of type String  }

Self.Attribute1:=Entity;

{produces an error because Attribute1 is of type String and Entity
   is of type object  }
```

Note (as seen in the examples above) that type checking is not done between object type variables. For example, if an Entity object is assigned to a variable defined as an object, an Activity or Resource object can be assigned to that same variable without causing any errors. However, the Expression may not work properly if the variable should contain an Entity object reference and another object type has been assigned to it.

There are a few special rules on object references. Self and Model object references can only be used as the first reference in an Expression statement. Something like

```
myobj:=Self.Activity.Self;
```

results in an error, since Self can only appear as the first object reference qualifier for the statement.

Getting and Freeing Resources Using Expressions

There are two system methods for getting and freeing Resources: **GetResource** and **FreeResource**. "SIMPROCESS System Methods" on page 465 summarizes the methods. These system methods provide the same basic capability as the Get Resource and Free Resource Activities. (See "Get Resource and Free Resource Activities" on page 133.) The main difference is that with the Get Resource system method, the Resource requested can be different for every Entity. The Get Resource Activity assumes each Entity entering the Activity requires the same Resources. Thus, if different Resources are needed, the Entity must be routed to a different Get Resource Activity that requests those Resources. The demonstration model, **H2O.spm**, which is included in the SIMPROCESS installation, compares the usual method of obtaining resources with the **GetResource** system method. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*.

GetResource

GetResource can be used in any Activity that can acquire Resources. (Thus, the Merge, Free Resource, Generate, Replenish Resource, and Dispose are excluded.) The Expression to get a Resource must go in the **Accept Entity** Expression of the Activity. **GetResource** may not be used in an Entity, Entity Type, or Resource Expression. The full command is

```
GetResource("Resource", "Units", "Tag");
```

The first parameter must be a String and is the Resource name. The second parameter can be a String, Integer, or Real. This is the number of units of the Resource to acquire. By allowing the second parameter to be a String, distributions can be used. The third parameter must be a String, but it is optional. This parameter corresponds to the tag used in the Get Resource Activity. The tag defaults to **any tag!** if the third parameter is omitted. If multiple **GetResource** system methods are used at an Activity, the Resources are obtained based on the rule set in the Resource usage of that Activity. The rules are **Any One Member**, **All Members**, **Reserve As Available**, and **Number of Members**. The default is **Any One Member**. Therefore, if multiple **GetResource** system methods are used, only one of the Resources will be acquired if the Resource acquisition rule has not been set to **All Members**. No Resources have to be listed in the Resource usage dialog for the Resource acquisition rule to be set.

When requesting Resources on the **Resources** tab of Activity properties, a particular Resource can only be added to the **Requirements** once. Thus, the selected acquisition rule always applies to different Resources. However, since a **GetResource** system method is equivalent to a Resource listed under **Requirements**, if two **GetResource** system methods in the same activity reference the same Resource then each **GetResource** request is treated in the same manner as if each referenced different Resources. For example, assume the following statements are in the Accept Entity expression of an Activity.

```
GetResource("Resource1", 1);
GetResource("Resource1", 1);
```

If the acquisition rule is **Any One Member**, then only one unit of Resource1 will be acquired since each statement is considered a "Member". If **All Members** is selected, then two units of Resource1 will be acquired. Note that if Resource1 only has one unit defined, then the above statements will generate a runtime error if **All Members** or **Reserve As Available** (which requires all members) are selected.

FreeResource

FreeResource can be used in any Activity that can release Resources. (Thus, the Merge, Get Resource, Generate, Replenish Resource, and Dispose are excluded.) Just like **GetResource**, **FreeResource** must be used in the **Accept Entity** Expression of the Activity, and **FreeResource** may not be used in an Entity, Entity Type, or Resource Expression. Both of these methods must go in the **Accept Entity** Expression because these methods set up the requests for the events to occur while the Entity is processing in the Activity. Therefore, order within the **Accept Entity** Expression does not matter. A **FreeResource** system method for a particular Resource can come before the **GetResource,** since this is occurring when the Entity is being accepted into the Activity. However, since these system methods operate like the Activities of the same name, the **FreeResource** for a particular Resource can be in a different Activity from the **GetResource** for that Resource. If the **FreeResource** is in a different Activity, the Resource will not be released until the Entity has completed processing in that Activity, even though the **FreeResource** system method is in the **Accept Entity** Expression. The full command is

```
FreeResource("Resource", "Tag", TRUE);
```

The first parameter must be a String. It is the name of the Resource to be released. The second parameter must be a String as well. This is the tag of the Resource to be released. The third parameter is a Boolean (thus only TRUE and FALSE are allowed). For consumable Resources, this determines whether the Resource should be consumed. The third parameter is optional. If omitted, it defaults to TRUE (meaning the Resource should be consumed). This parameter has no effect on non-consumable Resources. The second parameter (tag) is also optional. However, if the second parameter is omitted, the third parameter must also be omitted. The tag defaults to **any tag!** if the tag parameter is missing. There are two keywords for this system method: **AnyResource** and **AnyTag**. These can be used in the place of the Resource parameter and the tag parameter. So possible options are (without the last parameter):

- **FreeResource("Resource1", "myTag");**
- **FreeResource("Resource1", "AnyTag");**
- **FreeResource("Resource1");** this operates the same as the previous
- **FreeResource("AnyResource", "myTag");**
- **FreeResource("AnyResource", "AnyTag");**

- **`FreeResource("AnyResource");`** this operates the same as the previous

These are the same combinations that are available in the Free Resource Activity. The following example shows getting and freeing a Resource at a typical Delay Activity.

```
GetResource("Sales Rep", 1);
FreeResource("Sales Rep");
```

Combining Get and Free Expressions With Activities

These system methods can be used with the Get Resource and Free Resource Activities. Any Resource obtained with the **`GetResource`** system method can be released by a Free Resource Activity. However, it is important to note that tags used in a **`GetResource`** system method will not be available in a Free Resource Activity if those tags have not been used in a Get Resource Activity. Likewise, any Resource obtained with a Get Resource Activity can be released with a **`FreeResource`** system method.

Changing Resource Capacity With Expressions

IncreaseCapacity and **DecreaseCapacity** are system methods that will change the capacity of a Resource during a simulation run. "SIMPROCESS System Methods" on page 465 summarizes the methods. The methods apply to all Resources, whether consumable or not. Thus, **IncreaseCapacity** could be used to replenish a consumable Resource (however, the replenish to capacity option is not available). Just as with consumable Resources, the statistics for a Resource will reflect increases or decreases in capacity.

IncreaseCapacity

IncreaseCapacity can go in any type of Expression. When executed, it immediately increases the number of units of the Resources. The command is:

```
IncreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to increase. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to increase cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity

Just like **IncreaseCapacity**, **DecreaseCapacity** can go in any type of Expression. When executed, it decreases the capacity of the Resource as units of the Resource become available. If the number of units to decrease are less than the number of units idle, then the decrease happens immediately. If not, then the capacity units are decreased as units go to idle. Note that if the request for decrease is larger than the current capacity, SIMPROCESS will reduce the capacity to zero. However, SIMPROCESS will keep track of the number of units not yet decreased. For example, if Resource1 has a capacity of 3, and the capacity is decreased by 4, then the capacity of Resource1 is zero. Then, if the capacity of Resource1 is increased by one, the capacity of Resource1 will still be zero. This is because there was one unit of decrease still not applied to Resource1. The full command is

```
DecreaseCapacity("Resource1", 2);
```

The first parameter must be a String. It is the name of the Resource to decrease. The second parameter must be an Integer or a Real. Even though the second parameter can be a Real, the number of units to decrease cannot be fractional (even if the Resource is a fractional Resource).

DecreaseCapacity is not a substitute for the consuming of consumable Resources. Consumable Resources will be consumed when released. It is not necessary to use a system method. **DecreaseCapacity** is intended for non-consumable Resources.

User-Defined Functions

A **User-defined Function** will return the value of an Expression each time it is called from within the model. This allows re-use of a single function in multiple places in the model. The value returned must be a real number.

To create a User-defined Function, go to the **Define** menu, and select **Functions**. This opens a list box displaying any previously defined functions. The **Function Definition** dialog opens for **Add** and **Edit**. Enter a meaningful **Name** for the function. The **Expression** button will open up the Expression editor dialog as for any SIMPROCESS Expression. Type in the Expression here. The final line of the Expression should be a **RETURN** statement such as:

```
RETURN (Entity.Time * Activity.Factor);
```

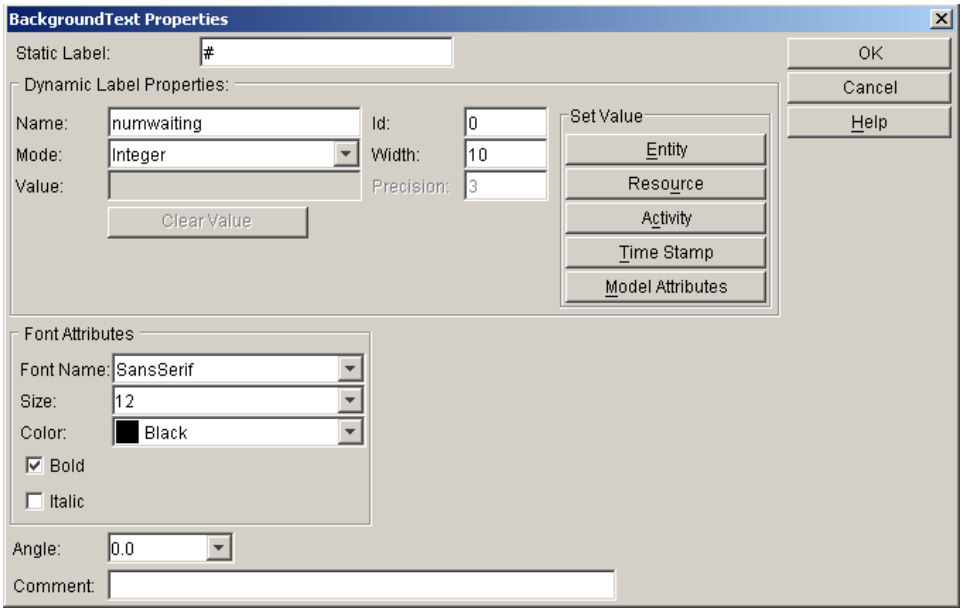
where **Entity.Time** and **Activity.Factor** are Attributes. Each time this function is called, it will return the value of the multiple of the two Attributes. Note that only REAL or INTEGER values can be returned. Also, the value received by the caller is always a REAL even if an INTEGER value followed the **RETURN**.

The **Name** entered for the User-defined Function will appear in every combo box of every Activity in the model where a statistical distribution can be entered. Also, User-defined Functions can be used in Expressions by using the **Function** system method. See “SIMPROCESS System Methods” on page 465.

The text of a function can be stored in an external file. See “Expression Editor,” beginning on page 231 for a discussion of that option.

Dynamic Labels

There are two types of background text in SIMPROCESS: static text and dynamic labels. Static text is used for annotating the model layout and does not change during simulation. Dynamic labels, as their name implies, are updated during simulation and are used to display information about changing properties of model elements. One way to update dynamic labels is through an **`UpdateDynamicLabel`** method in the Expression builder. (See "Background Text" on page 141 for a discussion of the other way to update dynamic labels.)



To update a dynamic label using Expressions, the dynamic label must have a unique combination of **Name** and **Id** number. Usually, **Id** number will be 0, unless two dynamic labels have the same **Name**. The name typed into the **Name** text box will not appear on the layout. It will only be used to reference the label from the Expression builder. The type of value with which the dynamic label will be updated must also be selected. The choice between String, Integer, and Real is made in the **Mode** combo box. If the value of the dynamic label is Real, **Width** and **Precision** must be specified in the corresponding value boxes. **Width** is the total number of digits that will be shown for the displayed value (including the decimal point), while **Precision** specifies the number of digits after the decimal point that will be displayed. If the **Width** is greater than the value being displayed, it will be padded with spaces on the left side. If the **Mode** is Integer, then only the **Width** field needs to be set.

Note that the **Value** field does not have to be empty to use **`UpdateDynamicLabel`**. The same dynamic label can be updated automatically and with **`UpdateDynamicLabel`**.

Once the dynamic label is defined, it can be updated by making a function call to the **`UpdateDynamicLabel`** method in the Expression builder. This method requires the following five arguments in this order:

`MasterEditor` — (typed as shown), reference to the main layout window.

`name` — a string (in quotes) used to designate the dynamic label in the **Name** text box of **Background Text** dialog. Make sure letter case is the same in both places.

`ID number` — the integer in the **Id** box of the **Background Text** dialog.

`text color` — a string (in quotes) of the color in which the text is to appear. A list of color names is found in "SIMPROCESS System Attributes and Methods," beginning on page 458. As with **`name`**, letter case must be as shown in the table. This overrides the font color selected in the properties dialog.

`value` — integer, real, or string value to display; type must correspond to what was selected in the **Mode** combo box of the **Background Text** dialog.

For example, to display a string showing the name of the Entity leaving a delay Activity, as well as a real value showing the amount of time this instance of an Entity spent at the Activity, and an integer showing number of Entities currently at that Activity, enter the following three commands in the Expression builder of the delay Activity at the Release Entity entry point:

```
UpdateDynamicLabel
   (MasterEditor,"num",0,"Orange",
   NumberIn);

UpdateDynamicLabel(MasterEditor,"name",0,
   "Aquamarine",Entity.Name);

UpdateDynamicLabel(MasterEditor,
   "lastdelay",0,"IndianRed",LastDelay);
```

For more information on Expression builder terminology and syntax, see "SIMPROCESS System Attributes and Methods," beginning on page 458.

Note that both dynamic and static text font Attributes can be changed during simulation by selecting the text and editing its properties. The change will take effect immediately after the **Background Text** dialog is closed and the simulation is resumed.

Interfacing With A Database

Expressions can retrieve information from an SQL database, and can modify an SQL database by inserting into tables, deleting from tables, and updating tables. Knowledge of SQL is required since all queries to the database are SQL queries.

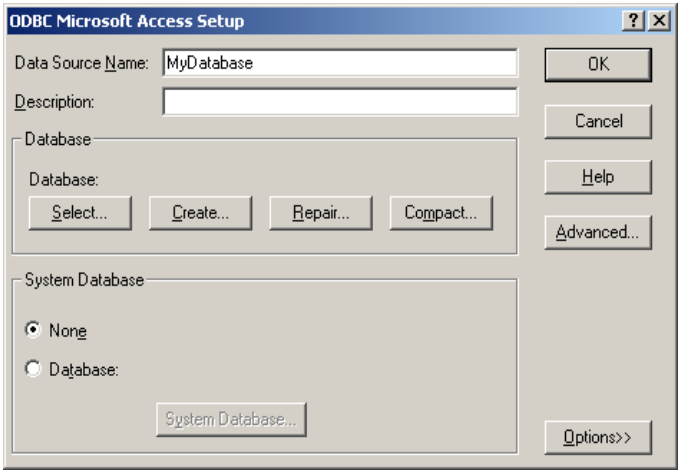
Setting Up Database Using Windows and Open Database Connectivity (ODBC)

When using Windows, the database must have a Data Source Name (DSN) specified in ODBC before SIMPROCESS can communicate with a database. Chapter 2 of the *Getting Started Manual* has detailed instructions on creating a DSN for the database that comes with SIMPROCESS. A similar procedure is followed for every database that is to communicate with SIMPROCESS in this way. However, instead of using the DSN **SimProcessDatabase** (which is for the database that comes with SIMPROCESS), another must be created. (Note, the **OpenDatabase** command on page 262 contains information on how to set up database connections for non-Windows systems.)

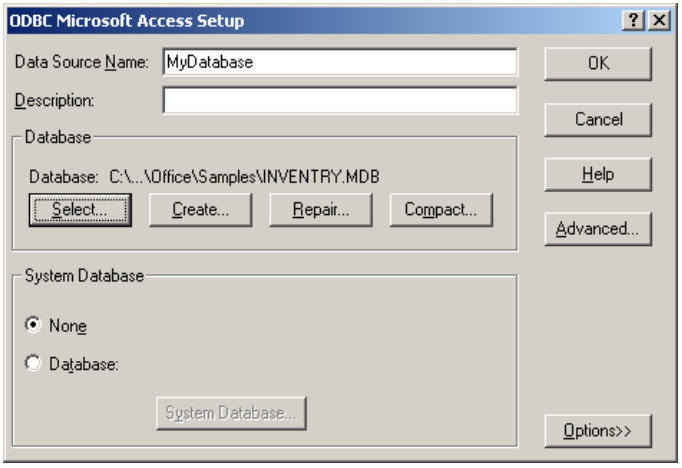
To create the DSN:

1. Open the ODBC control panel (on Windows 2000 and XP it is under the Administrative Tools control panel).
2. Select the **User DSN** tab and click on **Add**.
3. Select the appropriate driver for the database (for example, **Microsoft Access Driver**) and click **Finish**.

Clicking **Finish** brings up a dialog where the DSN is entered. The example below shows a DSN called **MyDatabase**.



Once a DSN has been entered, click the **Select** button. Browse to the location of the database, and, when found, click **OK**. The database will appear above the **Select** button.



Continue to click **OK** until ODBC is closed. The DSN created will be used by SIMPROCESS to communicate with the selected database. A unique DSN is required for every database that will interface with SIMPROCESS.

Database System Methods

There are six database-related System Methods which can be used in Expressions. (See "SIMPROCESS System Methods" on page 465.)

- OpenDatabase
- CloseDatabase
- ReadFromDatabase
- WriteToDatabase
- GetNext
- GetResult

OpenDatabase

OpenDatabase is used to create a connection between SIMPROCESS and a database. This must be done before any other database System Methods are used (**Start Simulation** Expression is a good place to use it). Before using the method an Attribute must be defined (normally a Model Attribute) of type Object. (See "User Defined Attributes" on page 215.) This Attribute will be used as a reference to the database connection. The syntax for Windows with ODBC is

```
Model.ObjectAttribute := OpenDatabase("DSN", "UserName",
"Password");
```

where **DSN** is the **DSN** created in ODBC. **UserName** and **Password** are optional. These are only required if the database requires them for access.

Alternatively, a database properties file can be used. This file should be similar to the **sProcDB.properties** file in the **SPUser** directory. This file is used to connect SIMPROCESS to the database that comes with SIMPROCESS. (Note, do not modify **sProcDB.properties**. Copy the file before making changes.) A database properties file must be used when not using Windows and ODBC; however, a database properties file can be used with Windows and ODBC instead of the above procedure. Below is the contents of **sProcDB.properties**.

```
jdbc.drivers=sun.jdbc.odbc.JdbcOdbcDriver

jdbc.url=jdbc:odbc:SimProcessDatabase

jdbc.username=""

jdbc.password=""
```

Simply change each of the properties to reflect the protocols needed for the system. If using a database properties file with Windows and ODBC, the properties are the same except the end of the **url** property is the DSN set up in ODBC. When using a database properties file the syntax is:

```
Model.ObjectAttribute := OpenDatabase("PropertiesFileName");
```

where **PropertiesFileName** is the name of the database properties file. If the database properties file is not in the **SPUser** directory, the **PropertiesFileName** must include the complete path.

If the connection is successful, the Attribute will contain a reference to the connection. Note that the connection is only valid for the model that created the connection. If another model needs to use the same database, that model must create its own connection.

CloseDatabase

CloseDatabase is used to close a connection to a database. This normally occurs at the end of a simulation (**End Simulation** Expression). The syntax is

```
CloseDatabase(Model.ObjectAttribute);
```

The only parameter is the Object Attribute that was used in the **OpenDatabase** system method that created the connection.

ReadFromDatabase

ReadFromDatabase gets information from a database and places the information into a **Result Set**. **GetNext** and **GetResult** are used to assign the data from a **Result Set** to Attributes or local variables in the model. The syntax is

```
ReadFromDatabase(Model.ObjectAttribute, "ResultSetName",
"SQLQuery");
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **ResultSetName** is a unique string identifier for the **Result Set** created by the query. **SQLQuery** is a string and is the query that creates the **Result Set**. Normally the query would start with the **SELECT** command.

WriteToDatabase

WriteToDatabase is used to modify the tables of the database. Nothing is returned. The syntax is

```
WriteToDatabase(Model.ObjectAttribute, "SQLQuery");
```

Model.ObjectAttribute is the Object Attribute that was used in the **OpenDatabase** system method that created the connection. **SQLQuery** is a string and is the query that modifies the tables of the database. This query can start with **INSERT**, **UPDATE**, or **DELETE**.

Note that **WriteToDatabase** can slow the simulation as table sizes increase. Also, be careful when using **WriteToDatabase** if there is the possibility the simulation will be stopped early by user

intervention. Updates to the database can lag behind the simulation. Thus, if the simulation is stopped early there is the potential that the **CloseDatabase** command would be executed before all the **WriteToDatabase** commands have finished. The consequence would be an error that could possibly crash SIMPROCESS. Omit the **CloseDatabase** command if this scenario might occur. If the **CloseDatabase** command is omitted, SIMPROCESS will not release the database until SIMPROCESS is closed.

GetNext

GetNext controls the position within a **Result Set**. **Result Sets** are simply tables of data. The columns are the fields requested in the SQL query. For instance, if the query was "**SELECT CallTime, WrapUpTime FROM Times**" the columns in the **Result Set** would be **CallTime** and **WrapUpTime**. **GetNext** sets the row of the **Result Set**. So **GetNext** is used in conjunction with **GetResult**. **GetResult** gets a value from the table (**Result Set**) once the row has been set. When a **Result Set** is first created by a **ReadFromDatabase**, the row pointer in a **Result Set** is pointing to before the first row. Thus, **GetNext** must be called before **GetResult**. The syntax is

```
BooleanVar := GetNext("ResultSetName");
```

BooleanVar is any Attribute or local variable defined to be a BOOLEAN. TRUE is returned if the next row exists, FALSE if not (at the end). **ResultSetName** is the user selected name given to a **Result Set** by a **ReadFromDatabase**.

Note that **GetNext** only moves forward through the rows. Going backwards is not possible. The only way to go back to the beginning of a **Result Set** is to execute again the **ReadFromDatabase** that created the **Result Set**.

GetResult

GetResult assigns a value from a **Result Set** to an Attribute or local variable in the model. The value comes from the current row of the **Result Set**. The current row is set by **GetNext**. The syntax is

```
Variable := GetResult("ResultSetName", "Field");
```

Variable can be an Attribute or a local variable. **ResultSetName** is the user-selected name given to a **Result Set** by a **ReadFromDatabase**. **Field** is the field from the database (column of the **Result Set**) that has the desired value.

The type of the value returned (INTEGER, REAL, BOOLEAN, or STRING) to **Variable** must match with the type of the **Variable**. Note that only INTEGER, REAL, BOOLEAN, and STRING values can be placed in a **Result Set**.

Database Example

The following are several examples on how to use the database System Methods. They are categorized by Expression type.

Start Simulation Example

This example assumes two real Model Attributes (**CallTime** and **WrapUpTime**) have been defined. Each of the Model Attributes have an array size that is equal to or larger than the number of values returned by the query. The values are placed in array Model Attributes because the values need to be referenced throughout the simulation. Also an object Model Attribute (**DatabaseConn**) was defined for the connection. Note that in the SQL query double quotes are required around the table name **Times Table** (for MS Access). Double quotes can be placed in strings by using \".

```
SQLString : STRING;
count : INTEGER;
Model.DatabaseConn := OpenDatabase("MyDatabase");
SQLString := "SELECT CallTime, WrapUpTime FROM \"Times Table\"
   WHERE Month = 12";
ReadFromDatabase(Model.DatabaseConn, "Times", SQLString);
count := 0;
WHILE GetNext("Times")
   Model.CallTime[count] := GetResult("Times", "CallTime");
   Model.WrapUpTime[count] := GetResult("Times", "WrapUpTime");
   count := count + 1;
END WHILE;
```

End Simulation Example

This example just shows closing a connection.

```
CloseDatabase(Model.DatabaseConn);
```

Accept Entity Example

In this example an Entity enters an Activity and gets its delay time from the database. This assumes the **WHILE** loop in the **Start Simulation** example was not performed.

```
SQLQuery : STRING;
IF GetNext("Times")
   Entity.Delaytime := GetResult("Times", "CallTime");
ELSE {will read again to start over if no more times are found}
   SQLQuery := "SELECT CallTime, WrapUpTime FROM \"Times Table\"
      WHERE Month = 12";
```

```
      ReadFromDatabase(Model.DatabaseConn, "Times", SQLQuery);
      IF GetNext("Times")
         Entity.Delaytime := GetResult("Times", "CallTime");
      END IF;
   END IF;
```

Release Entity Example

This example shows writing to a database. The processing time of the Entity for the Process is placed in the database in a table named **ProcessTimes**. The simulation time the Entity entered the Process was stored in an Entity instance Attribute called **StartTime**.

```
SQLString : STRING;
time : REAL;
time := SimTime - Entity.StartTime;
SQLString := "INSERT Into ProcessTimes (ProcessTime) VALUES (" +
   REALTOSTR(time) + ")";
WriteToDatabase(Model.DatabaseConn, SQLString);
```

Accessing Statistics During Simulation

There are times when it is useful to obtain the value of statistics during a simulation. For example, the value of certain statistics can be used to alter simulation flow, values can be placed into a user-defined database, or statistical values can be used in optimization. Any statistic collected during the simulation run can be accessed. This is done using various System Methods. (See “SIMPROCESS System Methods” on page 465.) There are nine System Methods for accessing statistics:

- GetActivityStatistic
- GetActivityByEntityStatistic
- GetAttributeStatistic
- GetCostStatistic
- GetEntityStatistic
- GetResourceStatistic
- GetResourceByActivityStatistic
- GetTimeStampStatistic
- GetTotalCostStatistic

The value of the statistic can be obtained for a specific replication, or the average or sum of replications can be obtained. The value of a specific replication can only be obtained if that replication has been run or is in the process of running. For example, the value for replication 2 is not available if replication 1 is the replication currently running. Also, the average and sum of replications are not available if only one replication is run. A value of -1 returns the average of replications, and a value of -2 returns the sum of replications.

GetActivityStatistic

`GetActivityStatistic` returns the value of a statistic for an Activity that has **Collect Activity Statistics** selected either globally or on the Activity properties. (See “Default Performance Measures” on page 163.) The syntax is

```
GetActivityStatistic("Activity Name", "Statistic", "Value Type",
Replication);
```

where **Activity Name** is the name of the Activity or Process, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See “Statistic Types” on page 507.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetActivityStatistic("Process4", "tokenlevel", "Avg", 1) returns the average number of Entities in Process4 for replication 1.

GetActivityStatistic("Process4", "tokendelay", "Max", 1) returns the maximum Entity cycle time for Process4 for replication 1.

GetActivityStatistic("Sales", "tokenwaitdelay", "Avg", -1) returns the average across replications of the Entity wait for Resources in the Activity "Sales".

GetActivityByEntityStatistics

GetActivityByEntityStatistic returns the value of a statistic for an Activity and that has **Collect Activity By Entity Statistics** selected either globally or on the Activity properties. (See "Default Performance Measures" on page 163.) The syntax is:

```
GetActivityByEntityStatistic("Activity Name", "Entity Name",
"Statistic", "Value Type", Replication);
```

where **Activity Name** is the name of the Activity or Process, **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 507.) All the statistic types for Activity by Entity statistics start with "by". **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetActivityByEntityStatistic("Process4", "Sales Calls", "bytoken.delay", "Avg", -1) returns the average cycle time across replications of the Entity "Sales Calls" in the Process "Process4".

GetActivityByEntityStatistic("Process4", "Sales Calls", "bytokenin", "Max", 2) returns the number of "Sales Calls" Entities that entered the Process "Process4" in replication 2. Although other Value Types are available, the maximum value is the value of interest since the number of Entities entering are just counted.

GetAttributeStatistic

GetAttributeStatistic returns the value of an Attribute that is being monitored for statistics. On the Attribute properties either **Observation Based** or **Time-Weighted** must be selected for **Statistics Types**, and at least one of the **Report Requests** must be selected. (See "Globally Defining an Attribute from the Menu" on page 216.) The value returned will be based on the **Statistic Type** selected on the Attribute properties (**Observation Based** or **Time-Weighted**). The Attribute name must be unique among

the user-defined Attributes that are being statistically monitored. The syntax is:

`GetAttributeStatistic("Attribute Name", "Value Type", Replication);`

where **Attribute Name** is the name of the Attribute. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

`GetAttributeStatistic("ProcessingTime", "Avg", 1)` returns average value for the Attribute "ProcessingTime" for replication 1.

`GetAttributeStatistic("ProcessingTime", "Max", -1)` returns maximum value across replications (that is, the maximum of the averages for each replication) for the Attribute "ProcessingTime".

GetCostStatistic

`GetCostStatistic` returns the Capacity or Absorption cost of a cost period. (See “Setting Up Cost Periods” on page 156.) The syntax is:

`GetCostStatistic("Period Name", "Cost Object 1", "Cost Object 2", "Cost Type", "Value Type", Replication);`

where **Period Name** is the name of the period, **Cost Object 1** is the name of the first cost object, **Cost Object 2** is the name of the second cost object, and **Cost Type** is either "Capacity" or "Absorption". **Cost Object 1** can either be a Resource name or an Activity name. **Cost Object 2** can either be an Activity name or an Entity name. Thus, the possible combinations of **Cost Object 1** and **Cost Object 2** are "Resource Name, Activity Name", "Resource Name, Entity Name", or "Activity Name, Entity Name". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for Value Type.

Some examples:

`GetCostStatistic("Week1", "Sales Rep", "Sales", "Capacity", "Max", -1)` returns the maximum Resource by Activity capacity cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales" is an Activity.

`GetCostStatistic("Week1", "Sales Rep", "Sales Calls", "Capacity", "Min", -1)` returns the minimum Resource by Entity capacity cost across replications for the cost period "Week1". "Sales Rep" is a Resource, and "Sales Calls" is an Entity.

`GetCostStatistic("Week1", "Sales", "Sales Calls", "Absorption",`

"Avg", 1) returns the Activity by Entity absorption cost for replication 1 for the cost period "Week1". "Sales" is an Activity, and "Sales Calls" is an Entity. Since this is the value for a replication, the maximum value is returned even though "Avg" is the **Value Type**.

GetEntityStatistic

GetEntityStatistic returns the value of a statistic for an Entity that has **Collect Entity Statistics** selected either globally or on the Entity type properties. (See "Default Performance Measures" on page 163.) The syntax is

```
GetEntityStatistic("Entity Name", "Statistic", "Value Type",
Replication);
```

where **Entity Name** is the name of the Entity, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 507.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetEntityStatistic("Sales Calls", "tokentotalborn", "Max", 1) returns the total number of "Sales Calls" Entities that were generated in replication 1.

GetEntityStatistic("Sales Calls", "tokendelay", "Avg", -1) returns the average "Sales Calls" cycle time across replications.

GetEntityStatistic("Sales Calls", "tokenholdlevel", "Max", 1) returns the maximum number of "Sales Calls" Entities that were in a hold condition for replication 1.

GetResourceStatistic

GetResourceStatistic returns the value of a statistic for a Resource that has **Collect Resource Statistics** selected either globally or on the Resource properties. (See "Default Performance Measures" on page 163.) The syntax is:

```
GetResourceStatistic("Resource Name", "Statistic", "Value Type",
Replication);
```

where **Resource Name** is the name of the Resource, and **Statistic** is the statistic type desired. The key words for the statistics available are found in Appendix G. (See "Statistic Types" on page 507.) **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetResourceStatistic("Sales Rep", "resrcidle", "Avg", -1) returns the average number of "Sales Rep" units idle across replications.

GetResourceStatistic("Sales Rep", "resrcbusy", "Max", 1) returns the maximum number of "Sales Rep" units busy for replication 1.

GetResourceByActivityStatistic

GetResourceByActivityStatistic returns the value of a statistic for a Resource that has **Collect Resource By Activity Statistics** selected either globally on the Resource properties. (See "Default Performance Measures" on page 163.) The syntax is:

```
GetResourceByActivityStatistic("Resource Name", "Activity Name",
"Value Type", Replication);
```

where **Resource Name** is the name of the Resource, and **Activity Name** is the name of the Activity. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetResourceByActivityStatistic("Sales Rep", "Sales", "Avg", -1) returns the average number of "Sales Rep" units busy at Activity "Sales" across replications.

GetResourceByActivityStatistic("Sales Rep", "Sales", "Max", 1) returns the maximum number of "Sales Rep" units busy at Activity "Sales" for replication 1.

GetTimeStampStatistic

GetTimeStampStatistic returns the value of a time stamp that has either **Collect Statistics**, Real-Time Trace Plot, or Real-Time Histogram Plot selected on the time stamp definition. (See "Time Stamps" on page 177.) The syntax is:

```
GetTimeStampStatistic("Start Key", "Stop Key", "Value Type",
Replication);
```

where **Start Key** is the starting key of the time stamp, and **Stop Key** is the stopping key of the time stamp. **Value Type** can be "Avg", "StDev", "Min", "Max", "Count", or "RunLength". **Replication** is the replication desired or the average or sum of replications.

Some examples:

GetTimeStampStatistic("start", "stop", "Avg", -1) returns the average of the time stamp with the start key "start" and stop key "stop" across replications.

GetTimeStampStatistic("start", "stop", "Count", 1) returns the number of observations of the time stamp with the start key "start" and stop key "stop" for replication 1.

GetTotalCostStatistic

GetTotalCostStatistic returns the total Capacity or Absorption cost of a Resource. The syntax is:

GetTotalCostStatistic("Resource Name", "Cost Type", "Value Type", Replication);

where **Resource Name** is the name of the Resource. If the **Resource Name** is "Total", the value returned is for all Resources. **Cost Type** is "Capacity" or "Absorption". **Value Type** can be "Avg", "StDev", "Min", or "Max" for **Replication** -1. If **Replication** is 1 or larger, the maximum value is returned no matter what is entered for **Value Type**.

Some examples:

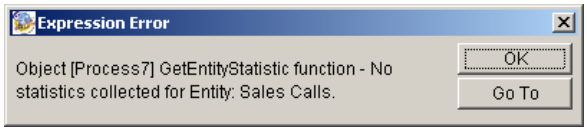
GetTotalCostStatistic("Sales Rep", "Absorption", "Max", 1) returns the total absorption cost of the "Sales Rep" Resource for replication 1.

GetTotalCostStatistic("Total", "Absorption", "Max", 1) returns the total absorption cost of all Resources for replication 1.

GetTotalCostStatistic("Total", "Capacity", "Avg", -1) returns the average total capacity cost of all Resources across replications.

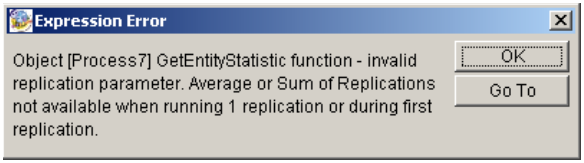
Statistic Errors

If the statistic requested is not found, a run time error will occur. This will occur if a statistic is requested for which no statistics collection was defined. In the following example no statistics were collected for the Entity "Sales Calls".


Expression Error
Object [Process7] GetEntityStatistic function - No statistics collected for Entity: Sales Calls.
OK
Go To

Another common error is to request the average of replication statistics when only one replication was

run or when the first replication is running. The average of replication can be requested during the simulation of replication 2 or higher, or after all replications have been completed. In the following example the average of replications (-1) was requested during the simulation of replication 1.


Expression Error
Object [Process7] GetEntityStatistic function - invalid replication parameter. Average or Sum of Replications not available when running 1 replication or during first replication.
OK
Go To

Requesting the statistic for a replication that is not currently running or has not yet run will not cause an error. The value zero will be returned.

Summary

This chapter described how Attributes are used in SIMPROCESS, and introduced Expression processing with a step-by-step example. The following was discussed:

- *Attributes* are variables of model elements whose value can change during a simulation run.
- *System* Attributes are those built in to SIMPROCESS. *User Defined Attributes* are custom-defined by users.
- *Object* Attributes identify the model element whose Attribute is being referenced.
- *Globally-defined* user Attributes are created for every model element of the same class (Activities, Resources, etc.).
  Locally-defined Attributes apply only to a single type of a model element.
- *Expressions* are user-written procedures which are invoked by SIMPROCESS at various events during a simulation run. An introduction to the basics of this language begins on page 226.
- *Object Attributes* are used in Expressions to qualify Attribute references.
- Numerous *System Methods* are available to add functions to Expressions.

CHAPTER 11

More Advanced Model Building

This chapter discusses the advanced schedules of the Generate activity and Resource downtime. Most real world scenarios do not operate at the same schedule 24 hours per day, 365 days per year. Thus, the ability to vary entity generation and the availability of resources is critical.

Defining a More Complex Generate Activity

A Generate Activity generates different types of Entities, or it can vary the schedule of entity generation for a single entity type.

Specifying the Active Period of Entity Release

The period that the entity release schedule is in effect can be limited by specifying Release *Start* and *End* dates. To do this, click on the **Start/End** tab and specify the **Start** and **End** dates.

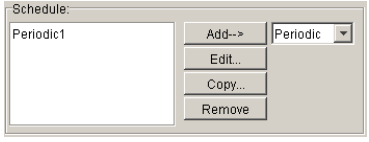
If **Start** and **End** dates are specified, the Generate Activity will not produce Entities outside of that time period.

The **Start** and **End** dates work in conjunction with the Start Date and End Date of a simulation run. So keep in mind that, if the simulation run dates are entirely outside of the period defined for the Generate release schedule, no Entities are generated during that simulation.

If a *Generation Start* date is not specified, SIMPROCESS sets the Start time to correspond to simulation start time. Similarly, if *Generation End* date is blank, it defaults to the simulation end time. So leaving the Generation **Start/End** fields blank ensures that the schedule is in effect for the entire simulation run.

Defining Schedules for a Generate Activity

The Generate schedule identifies the entity-generation pattern defined for an Activity. When a new schedule item is defined, it is added to the **Schedule** list box:



Each **Schedule** identifies an entity generation pattern of a specific type:

- **Periodic**: A periodic schedule generates a specified quantity of Entities at the end of a specified time period
- **Calendar**: Generates Entities according to a calendar schedule: weekly, monthly, etc.
- **Cyclical**: A detailed sequence of when Entities are generated
- **File**: A schedule defined in an external file
- **External**: Generates Entities based on inputs from an external source. External schedules are a plug-in capability that can be licensed separately from CACI.

Schedules are processed in parallel. If there are two schedules that overlap in time, SIMPROCESS processes both simultaneously.

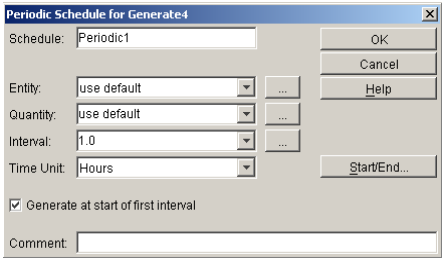
Click on **Add** to define a new schedule, or **Edit** to change the definition of the item highlighted in the schedules list box. When adding a new schedule, first identify the type of entity generation pattern by selecting from the **Schedule Type** combo box.

Copy duplicates the definition of the item highlighted in the **Schedule** list box. Use this when two or more similar schedules are needed.

Remove deletes the highlighted schedule.

Adding a Periodic Schedule

The periodic schedule defines a constant or statistical distribution of entity generation events per period:



The **Periodic Schedule** dialog contains the following items:

Schedule: Assign a meaningful name to the entity generation schedule. The default name assigned by SIMPROCESS is the same as the schedule type; in this case, **Periodic1**.

Entity specifies the type of entity to be generated by this schedule. **Use default** tells SIMPROCESS to generate the type of entity indicated in the **Generate Activity Properties** dialog. To specify a different type, click on the pull-down arrow for a list of entity types to choose from.

Quantity is the number of Entities to be produced at each entity generation by this schedule. Again, **use default** refers back to the value in the **Generate Activity Properties** dialog. See page 63 of the *SIMPROCESS User's Manual* for additional details on this field.

Interval defines the time between entity-generation events for this schedule.

Schedule **Start** and **End** define the effective period for this schedule.

The times in the **Start** and **End** fields apply just to this schedule. The **Start** and **End** dates for the schedule

must be within the **Start** and **End** dates specified on the **Generate Activity Properties** dialog. If a date is not entered for either **Start** or **End**, the corresponding value (if any) in the **Generate Activity Properties** applies.

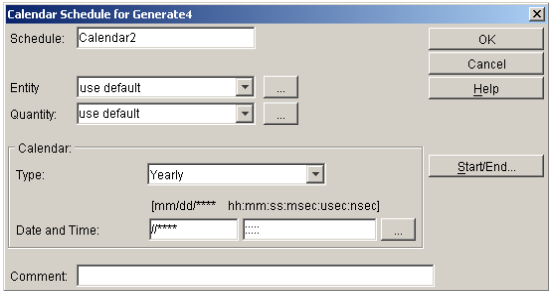
Count Limit sets the maximum number of Entities that can be generated by this schedule. A **Count Limit** value of 0 indicates that there is no limit.

If the **Count Limit** is reached, the Generate Activity may stop generating Entities for this schedule. This depends on the setting of the **Both must be reached** and **Generation End** fields.

Both must be reached, if marked, specifies that both the **Count Limit** and **Release End** date must be attained in order to terminate entity generation for this schedule. If the **Both must be reached** field is not marked, then reaching either **Generation End** or **Count Limit** terminates the schedule.

Adding a Calendar Schedule

To add a schedule that generates Entities based on the calendar, select **Calendar** under **Schedule Type** on the **Generate Activity Properties** dialog, and then click on **Add**:



The following types of entity-generation schedules can be specified in the **Calendar Schedule** dialog:

- **Yearly** - Entities are generated once every year, on a particular date
- **Monthly** - Entities are generated on a specific day in each month (e.g., 1st of the month)
- **Weekly** - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)
- **Daily** - Every day, generated at the specified time
- **Hourly** - Every hour, generated at the specified time
- **Date** - A specific date and time. This event will occur only once, at the specified date and time.

The **Calendar Schedule** dialog changes in appearance depending on the **Type** of schedule selected:

- If **Calendar Type** is **Weekly**, a list of the days of the week is added to the dialog.
- The heading above the **Date and Time** field changes to prompt for the information required for the **Type** schedule selected.

For example, if a **Daily** entity generation schedule is selected, a time of day must be entered in the **Date and Time** field.

Any information that does not apply to a **Daily** schedule, such as the date and year, is ignored.

As with all schedules, the **Generation Start** and **Generation End** dates can be used to further define the effective period for a Calendar generation schedule.

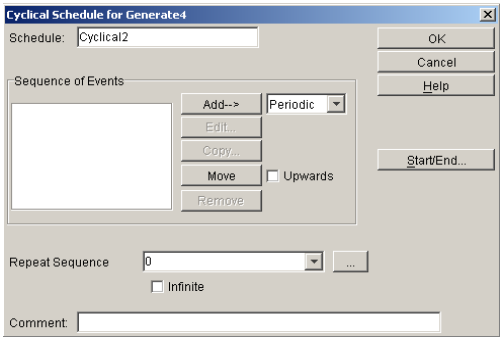
Defining Cyclical Schedules

Use the cyclical schedule to define a detailed sequence of entity generation cycles. For example, a week day-by-day, or a year month-by-month could be described. A unique period such as the holiday rush leading up to Christmas could be defined, where entity generation behavior differs markedly from the rest of the year.

A cyclical schedule is defined as a series of *cycles*. Each cycle describes a different entity generation sequence. In a sense, the cycle series is like a schedule of its own. But unlike the schedules defined for the Generate Activity as a whole, cycle events are processed *sequentially*, not in parallel. Since one cycle follows another, order is important. Cycles can be repeated as many times as is needed.

The following types of cycles can be defined:

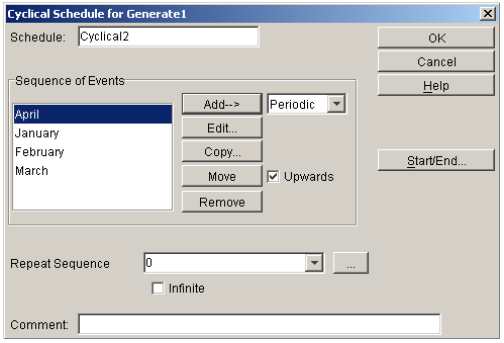
- **Periodic**. A constant or statistical distribution defining the time interval between events
- **Calendar**. Entity generation events scheduled at intervals based on the calendar, i.e., weekly, monthly, etc.
- **Single Event**. A one-time entity generation event
- **No Event**. A period where no Entities are generated
- **Cyclical**. A cycle within a cycle; that is, a more detailed breakdown within a schedule (e.g., the various periods within a single day — breakfast, meeting, coffee break, lunch — within a workweek described day-by-day).



Cycles are added to and modified from the **Cyclical Schedule** dialog.

The **Sequence of Events** dialog lists the cycle events defined for this cyclical schedule. The events are listed in the order in which SIMPROCESS will execute them. When a cycle is added, SIMPROCESS places it at the end of the list. The pattern can be rearranged using the **Move** command.

For example, here is a list of cycles defined out of sequence:



To move the April cycle to the end of the list, highlight April and click on the **Move** button three times. Each click of **Move** shifts the item down a row.

Cycles can be moved up in the list by checking the **Upwards** option before clicking the **Move** button.

Repeat Sequence tells SIMPROCESS how many times to *repeat* execution of the pattern of cycles. If **Infinite** is checked, SIMPROCESS will keep repeating the cycle pattern until **Generation End** is reached.

Note about Repeat Sequence

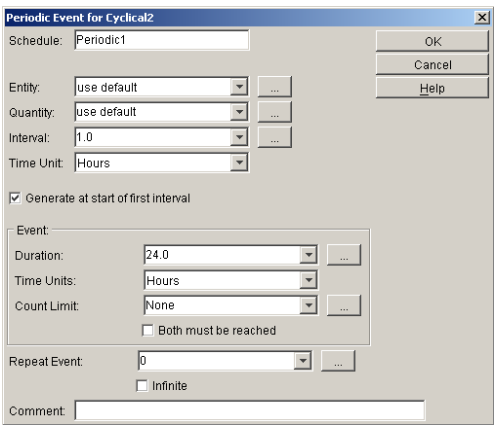
A value of *0* in the **Repeat Sequence** field tells SIMPROCESS to run through the list a single time, without repeating it. A value of 1 results in two passes through the **Sequence of Events**: the initial run-through and one repetition.

Do not confuse the number of *repetitions* with the number of *passes* through the list.

Refer to page 277 for descriptions of the **Generation Start** and **Release End, Count Limit**, and **Both must be reached** options.

Defining a Periodic Cycle

A periodic cycle defines a constant or statistical distribution of entity generation events. To define a periodic cycle in a cyclical schedule, select **Periodic** from the list of **Schedule** types, and then click on **Add**:



Defining a periodic cycle is similar to defining a periodic schedule (see page 277). The major difference is that duration of the cycle is not defined in terms of start and end dates. That is because the start time is under the control of the cyclical schedule of which the cycle is a part:

Duration is how long this cycle is in effect. A number can be entered or a value selected from the pull-down list for this field. **Time Units** specifies the time unit of the **Duration**.

The starting time of the event is determined by the following factors:

- The **Generation Start** date of the cyclical schedule
- The position of this cycle in the **Schedule of Events** in the **Cyclical Schedule** detail dialog
- The **Duration** of the cycles that precede this one.

Count Limit sets a maximum number of Entities that may be generated during this cycle. A value of *0* indicates no limit.

The **Both must be reached** checkbox, if marked, specifies that both the **Duration** and **Count Limit** must be reached before the cycle completes.

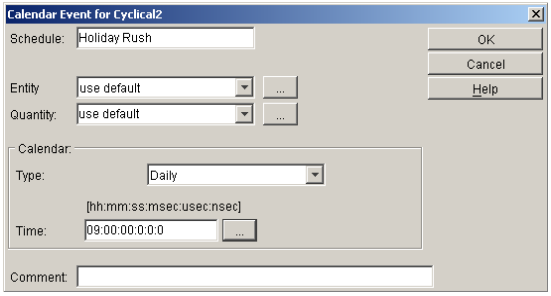
Note that selecting **Both must be reached** can result in a cycle of unknown duration. This happens if the **Count Limit** is not reached before the end of the **Duration** period. In that event, the cycle continues until either the **Count Limit** is attained, or the Generate Activity **Generation End** is reached.

Repeat Event tells SIMPROCESS how many times to repeat execution of this cycle. If **Infinite** is selected, SIMPROCESS will keep repeating the cycle until the schedule's **Generation End** date is reached.

- The **Entity, Quantity**, and **Interval** fields are used the same way they are in the **Periodic Schedule** detail dialog (see page 277).

Defining a Calendar Cycle

A calendar cycle defines entity generation events that repeat on either a daily, weekly, monthly, or yearly basis:



The dialog above shows a calendar cycle representing four days leading up to a festive holiday, when people are rushing to buy gifts for their loved ones. It's a daily schedule, beginning at 9 a.m. Note that there is no duration on calendar events. They will operate as long as possible. For the example above, since it is a Daily schedule, it will generate every day at 9 o'clock. Thus, any events listed after the Daily event in the Cyclical schedule will not execute, since the Daily event will keep generating.

As with the periodic cycle, the start time of a calendrical event is determined by the cyclical schedule in which the cycle is defined. However, *entity generation* is not triggered until the time that is indicated in the **Date and Time** field. If the trigger point is not reached while the cycle is in effect, no Entities are generated. For a further explanation, see "SIMPROCESS' Scheduling of Event Cycles" on page 283.

The **Date and Time** needed depends on the **Calendar Type** schedule selected:

- **Yearly.** Enter a date and time of day, but do not specify a year. Entity generation begins if the simulation reaches the specified date and time during this cycle.
- **Monthly.** Specify a day of the month and time of day, e.g., the first of the month, at noon. Entity generation begins if the simulation reaches the specified day and time while the cycle is in effect.
- **Weekly.** Select a day of the week (from a list that appears when **Weekly** is checked off) and a time of day. Entity generation begins if the simulation reaches that day and time during the cycle.
- **Daily.** Specify a time of day. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Hourly.** Specify the minutes and seconds of an hour. Entities are released if the simulation reaches this time of day while the cycle is in effect.
- **Date.** Specify a specific date and time. Entities are released if the simulation reaches this date and time while the cycle is in effect.

SIMPROCESS' Scheduling of Event Cycles

Calendar cycles must be carefully placed within the **Sequence of Events**. If the trigger time specified in the **Date and Time** field has already passed when SIMPROCESS invokes a cycle, entity generation may not occur.

For example, assume a cyclical schedule with a **Generation Start** date of January 1, 2004, and a **Generation End** date of March 31, 2004. The schedule contains the following **Schedule of Events** cycles:

- A periodic cycle event beginning on January 1, with a duration of 48 hours.
- A calendar cycle which is triggered monthly, on the 2nd of the month.

The simulation begins at midnight, January 1. The periodic cycle starts right away and lasts for 48 hours. At this point it is midnight, January 3rd, and the calendar cycle is implemented. What happens during this period?

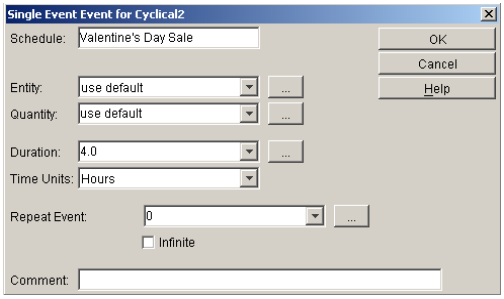
No Entities are generated by the calendrical event for January. Here is why:

1. On January 3rd of simulation time, SIMPROCESS acts on the calendrical cycle. It checks the **Date and Time** value (which is set to the 2nd of the month, at midnight) and compares it to the current date. SIMPROCESS determines that the trigger date has already passed and bypasses entity generation. The next possible trigger point is on February 2nd.
2. The calendar cycle continues until the end of the simulation or until the end of the active period for the Cyclical schedule.

Note that the Calendar event maintains control of the Cyclical schedule since there is no duration for the Calendar event.

Defining a Single Event Cycle

A Single Event cycle describes a one-time entity generation event:



A single event has the same parameters as a calendar cycle, except that when the event begins cannot be specified. A single event's starting date and time is dependent on the cycles that precede it in the pattern of cycles. Once the event is active, the generation occurs at the end of the duration.

Defining Inactive Time Periods

The **No Event** cycle defines a period of time during which no Entities are generated (for example, a holiday or weekend). The period of inActivity begins at whatever time SIMPROCESS invokes the **No Event** cycle.

Defining Specific Entity Generation Events in a File

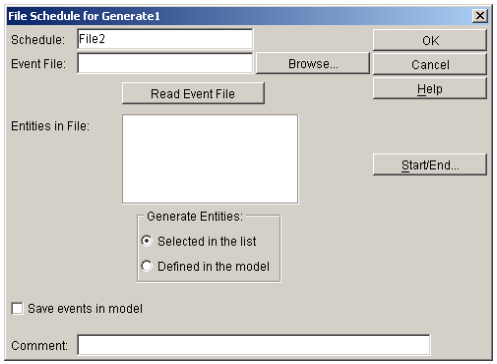
Entity generation events can be specified in an event file. An event file is created with a text editor or some other means independent of SIMPROCESS (such as a user written program). With an event file, a simulation can be run using data captured outside of SIMPROCESS.

For example, most mail order businesses use computer systems to track customer sales information. This information is stored in some kind of database. This information can be extracted from the database and a series of entity generation events defined that precisely matches customer activity for an actual

day, week, month, etc. (Note that the database can also be read directly by SIMPROCESS. See “Interfacing With A Database” on page 260.)

Each record in an event file defines one entity generation event. To learn how to define entity generation events, see Appendix G–External Event Files, on page 498.

Use the **External File** schedule to identify an event input file to SIMPROCESS:



To identify the event file, click on the **Browse** button to the right of the **Event File** box. Use the resulting dialog to find and select the file.

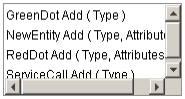
The **Read Event File** button causes SIMPROCESS to read the event file, checking for syntax errors and building a list of the entity types and attributes referred to in the file. The **Read Event File** button must be clicked to complete the definition of the event file.

Identifying Entity Types to be Generated

An event file can contain records referring to many different entity types. An event record can even refer to a type of entity that has not yet been defined in the model and to entity instance attributes that have not been defined in the model. Which entity types SIMPROCESS should generate during simulation can be specified precisely.

Select the **Generate Entities** option that indicates which of the entity types referenced in the event file are to be generated:

- **Defined in the model** tells SIMPROCESS to generate Entities for every event record that specifies an entity type already defined in the model.
- **Selected in the list** tells SIMPROCESS to generate Entities only for the types highlighted in the entity type list.



- If the event file refers to an entity type that is not defined in the model, it flags the type name. For example:

```
GreenDot Add(Type)
```

- Selecting this type will cause SIMPROCESS to add the entity type to the model.
- If the entity in the event file refers to entity instance attributes that have not been defined in the model, this is flagged as well. For example:

```
NewEntity Add(Type, Attributes);
```

- Note that attributes are tied to Entities. Entity instance attributes cannot be added without adding the entity type.

To select the entity types to be used:

- Highlight the listed type name. To highlight several types, press and hold the **Ctrl** key while clicking on each item.
- To deselect a type, click on it again while pressing the **Ctrl** key.

Saving Events

The option **Save events in model** determines whether the event file is needed for simulation. The option defaults to not selected. Not being selected means the event file will be read at simulation time. Thus, the file is required to run the simulation. If the option is selected, then the events are saved as a part of the model, and the file is not needed for simulation. However, saving events as a part of the model could significantly increase the size of the model file and increase the amount of time needed to load the model. If events are saved, the **Read Event File** button must be exercised if the event file changes. Otherwise, the simulation will not run with the events from the new file. Note that if the events are not saved, and the event file changes, the events for the simulation will change. But, doing this without intentionally reading the event file using the **Read Event File** button assumes that the Entities and attributes used in the new file are the same as the previous file.

Adding an External Schedule

An external schedule allows a remote application to cause the generation of Entities within a SIMPROCESS model. This is a plug-in capability that can be purchased separately from CACI. Typical uses for external schedules include connecting decision support or operational systems to a

SIMPROCESS simulation model to see how a model is affected by the randomness of real work applications in use rather than just randomness from statistical distribution functions. Other uses may include custom training software that allows students to interact with the simulation based on things they see occurring in the model – hence, influencing the remaining simulation.

An external schedule changes the normal operation of a simulation. If SIMPROCESS detects an external schedule within a model (and the appropriate license has been purchased), then the ending date and time specified in the **Run Settings** (page 90) is no longer active. Normally, if there are no more simulation events to process, then the end simulation event (which is based on the ending date and time specified in the **Run Settings**) is executed. When an external schedule is present and there are no more simulation events to process, the simulation suspends execution until an external schedule is signaled to generate Entities. Note that simulation time does not advance while simulation processing is suspended.

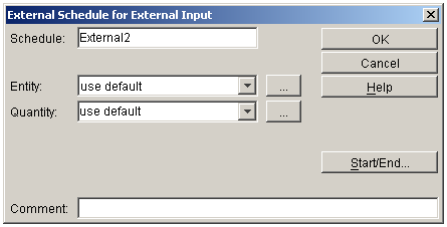
There are three ways to stop a simulation that contains an external schedule. The first is to manually stop the simulation using the Stop button, the F9 key, or **Simulate/Stop**. The second way is to route Entities to a Dispose Activity that has a maximum entity count set (page 69). When the maximum has been reached, the simulation will stop. The final way is to call the `stopSimulation` method of SPServerFactory (page 289).

Three actions must be accomplished before the start of the simulation in order to use an external schedule. The last two can be done before SIMPROCESS is started and can remain operational even though SIMPROCESS is closed and reopened.

- Create the external schedule in a Generate Activity
- Start the Java RMI Registry
- Start SPServer.

External Schedule Setup

Use the **External** schedule dialog to set the default **Entity** and **Quantity.**



The **Entity** and **Quantity** specified on the dialog can be overridden by the external application. Multiple external schedules can be specified in a single generate Activity or in different generate Activities.

Java RMI Registry

The Java RMI Registry must be started before SPServer or the simulation is started. This is because Java RMI is the protocol used to communicate between the external application and SPServer, and between SPServer and SIMPROCESS. The RMI Registry program (`rmiregistry`) is located in the Java Runtime Environment (JRE) included with SIMPROCESS. To start the RMI Registry locally, select **Tools/Remote/Start RMI Registry.** Note that once the RMI Registry has been started, it will remain active until SIMPROCESS is closed. Alternatively, a batch file or UNIX shell script can be constructed in the SIMPROCESS directory, because the RMI Registry program is required to have in its classpath the locations of files referenced by server processes. Here are some examples of what should be contained in those files:

In a Windows batch file:

```
set CLASSPATH=SPSYSTEM\simprocess.jar;SPSYSTEM\SPRemote.jar
rmiregistry
```

In a UNIX shell script using the Bourne shell or a derivative:

```
CLASSPATH=SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
export CLASSPATH
rmiregistry
```

In a UNIX shell script using the C shell or a derivative:

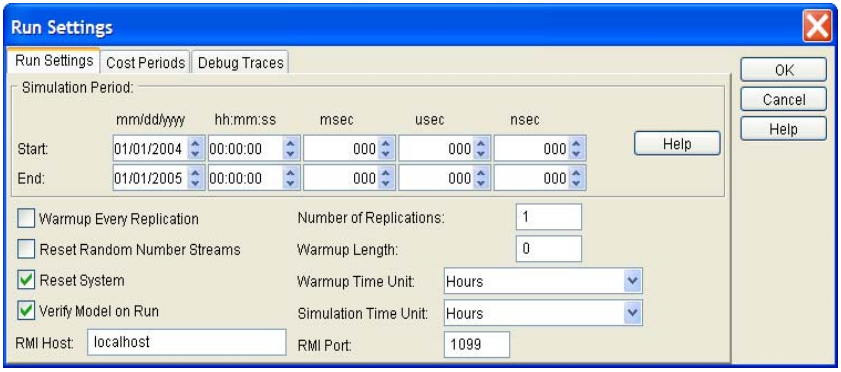
```
setenv CLASSPATH SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar
rmiregistry
```

Sample batch files and scripts are located in the `SPUser\SampleFiles` directory. `SPUser` is located in the SIMPROCESS installation directory. The sample batch and script files are intended to be run from the SIMPROCESS installation directory.

SPServer

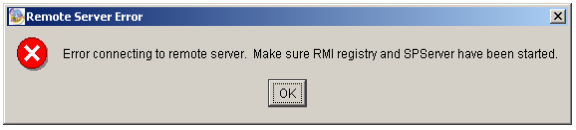
SPServer instantiates a single object called SPServerFactory. SPServerFactory creates instances of a server for each simulation that has an external schedule. SPServerFactory keeps track of which server instance is associated with which simulation. Thus, the user only needs to interface with SPServerFactory through a set of public methods. The user is responsible for creating the interface to SPServerFactory. If RMI Registry is running on the same system as SIMPROCESS, select **Tools/Remote/Start SPServer** to start SPServer. To start SPServer from a command line in the directory in which SIMPROCESS was installed, type the command `jre\bin\java -classpath SPSYSTEM/simprocess.jar:SPSYSTEM/SPRemote.jar com.caci.remote.SPServer` (use backslashes and semicolons on Windows). Once the command has been executed, SPServerFactory is available through the Java RMI Registry using its bound name of "SPServer."

To run RMI Registry and SPServer on a host other than the host on which SIMPROCESS is running, and/or to specify a TCP port other than the default (1099), make the appropriate changes in the **Run Settings**. The sample files to start RMI Registry and SPServer can be copied from `SPUser\SampleFiles` to the appropriate system.



Running The Simulation

With the above steps complete, the simulation can be started. The simulation must be started before the external application attempts to communicate with SIMPROCESS. If not, an error will occur and the simulation will be terminated.



SPServerFactory API

When the simulation is running, the external or remote application can begin communicating with SIMPROCESS. In order to do this, the application must have a reference to SPServerFactory. However, since SPServerFactory is remote to the application, the Stub class for SPServerFactory must be used. Stub classes are created by RMI and contain references to the methods of SPServerFactory that are available remotely. The code fragment below is from an example remote application and shows how to get a reference to SPServerFactory_Stub.

```
import java.rmi.*;

import java.rmi.server.*;

import com.caci.remote.*;
```

```
public class ExternalApp

{ public static void main(String args[])

 { try

  { SPServerFactory_Stub spServer = null;

  try {spServer = (SPServerFactory_Stub)Naming.lookup    ("rmi://localhost/
       SPServer"); }

   catch (Exception e) { e.printStackTrace(System.out); }

   }
```

The name `localhost` can be replaced with any valid entry that will resolve to the system on which SPServerFactory is running. Note that the `Naming.lookup` method throws a `NotBoundException` and a `MalformedURLException` so this command must be within a `try` block.

The class `com.caci.remote.SPServerFactory` has three public methods for communication with SIMPROCESS models:

```
public double getSimTime(String modelName)

   throws RemoteException;


public boolean generateEntity(

   String modelName, String generate,

   String schedule, double time, int quantity)

         throws RemoteExeption;

public boolean stopSimulation(String modelName)

         throws RemoteException;
```

`getSimTime` returns a `double` representing the current simulation time. The time unit of this number is the simulation time unit specified in the **Run Settings**. Its single parameter, `modelName`, is the name of the simulation model (the same as its filename without the .spm extension).

`generateEntity` returns a `boolean` indicating success or failure. Its parameters are as follows:

- `modelName` is the name of the simulation model (the same as its filename without the .spm extension)
- `generate` is the name of the Generate Activity

- `schedule` is the name of the External schedule within the Generate Activity
- `entity` is the name of the Entity to create
- `time` is the simulation time at which the generation event should occur
- `quantity` is the number of Entities to generate for this generation event

The parameters `entity` and `quantity` can default to the **Entity** and **Quantity** specified on the external schedule dialog. A value of `null` or `""` for `entity` will cause the default to be used. A value of `0` for `quantity` causes the default quantity to be used. The `time` parameter can default to the current simulation time by passing a value of `-1`.

`stopSimulation` returns a `boolean` indicating success or failure. `modelName` is the only parameter.

All methods throw a `RemoteException`.

External Application Example

The code below is a simple example of an external application communicating with SIMPROCESS. In this example, Remote is the name of the model (Remote.spm). The `for` loop runs from 1 to 10. For 1 and 2, the `generateEntity` method specifies all the parameters except `quantity`. The `generateEntity` method for 3, 4, and 5 specifies all the parameters. The `generateEntity` method for 6 through 10 only specifies the `model`, `generate`, and `schedule` parameters. The remaining parameters are set for defaults. The `generateEntity` method after the `for` loop calls the StopSim schedule. This schedule is set to generate a StopSim entity, which enters a Dispose Activity with a maximum entity count of 1, thus stopping the simulation. See Chapter 5 of the *SIMPROCESS Getting Started Manual* for instructions on running this example. The code (`ExternalApp.java`) is in the `SPUser\SampleFiles` directory. Also, in the `SPUser\SampleFiles` directory is `ExternalApp2.java`. This application is exactly the same as `ExternalApp.java`, but it uses `stopSimulation` to end the simulation.

```
package com.caci.demo;
import java.rmi.*;
import java.rmi.server.*;
import com.caci.remote.*;
public class ExternalApp {
  public static void main(String args[]) {
     SPServerFactory_Stub spServer = null;
     boolean goodEvent = false;
     try {
       spServer = (SPServerFactory_Stub)Naming.lookup("rmi://localhost/
         SPServer");
     }
```

```
      catch (Exception e) {
        e.printStackTrace(System.out);
      }
      try {
        if (spServer != null) {
          for (int i = 1; i < 11; i++) {
            double time = spServer.getSimTime("Remote");
            time = time + 10.0;
            if (i < 3) {
              goodEvent = spServer.generateEntity("Remote", "Generate1",
                "External1", "Entity9", time, 0);
              }
            else if (i < 6) {
              goodEvent = spServer.generateEntity("Remote", "Generate1",
                "External1", "Entity6", time, 2);
            }
            else {
              goodEvent = spServer.generateEntity("Remote", "Generate1",
                "External1", null, -1, 0);
            } // end of inner if
            if (!goodEvent) {
              System.out.println("Generate event failed");
            }
            try {
              Thread.sleep(2000);
            }
            catch (Exception e) { }
          } // end of for loop
          goodEvent = spServer.generateEntity("Remote", "Generate1",
            "StopSim", null, -1, 0);
        } // end of outer if
      } // end of try block
      catch (RemoteException re) {
        re.printStackTrace(System.out);
      }
    } // end of main
  } // end of ExternalApp
```

External Schedule Errors

If the call to `getSimTime` is not successful, a `-1` will be returned. If the call to `generateEntity` is not successful, `false` will be returned. Error messages from SPServerFactory or one of the server instances will be in the file `server.log` in the SIMPROCESS directory. If the error occurred within SIMPROCESS, the error messages will be in `simprocess.log` or `simprocess.err` in the SPSYSTEM directory.

Generate Activity Summary

The Generate Activity generates the Entities that are processed in a SIMPROCESS simulation:

The number of Entities generated at each generation event and the frequency of entity generation events may be expressed as either constant numbers or statistical distributions.

Schedules of discrete entity generation events can be defined. Schedules are classified as:

- *Periodic*: A constant or statistical distribution of generation events per time unit.
- *Calendar*: Weekly, monthly, etc., events.
- *Cyclical*: A detailed sequence of generation events.
- *File*: A schedule defined in an external file.
- *External*: A schedule that receives generation signals from an external application.

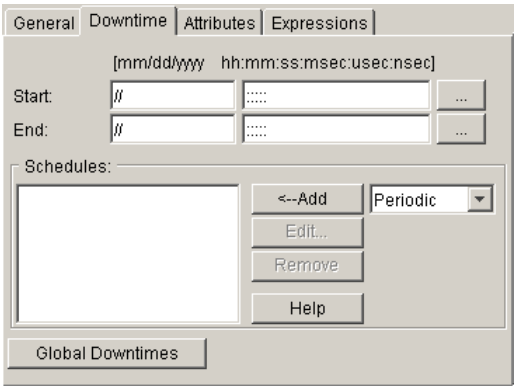
Cyclical schedules are further broken down into *cycles*, each of which describes a different entity generation event. Cycle events are processed sequentially. This differs from other Generate schedules, which are processed in parallel.

Resource Downtime

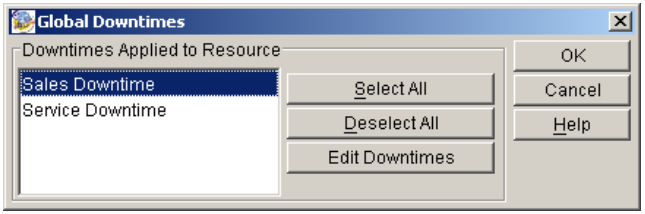
Resource Downtime determines when a resource is unavailable. Resource Downtime can be defined locally or globally. A Resource can have multiple global and one local Resource Downtime. Each global Resource Downtime for a particular Resource and the local Resource Downtime for the Resource operate independently. Thus, each can have different **Start** and **End** dates and times, and each can have different **Schedules**.

Local Resource Downtime

Local Resource Downtime is defined on the **Downtime** tab of the Resource properties dialog. Downtime defined on the **Downtime** tab of a Resource properties dialog will only apply to the Resource currently being edited.

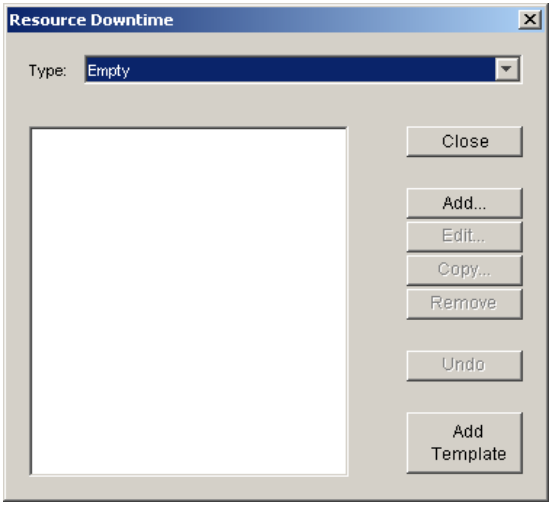


The global Resource Downtimes can be accessed while defining a local Resource Downtime. There is a **Global Downtimes** button on the **Downtime** tab of the Resource Properties dialog that displays a dialog that lists the global Resource Downtimes defined in the model. The global Resource Downtimes that are applied to the Resource are selected and can be modified. The global Resource Downtimes can be edited by selecting the **Edit Downtimes** button.



Global Resource Downtime

Global Resource Downtimes can be applied to any Resource in the model. They are defined by selecting the menu item **Define/Resource Downtimes....**

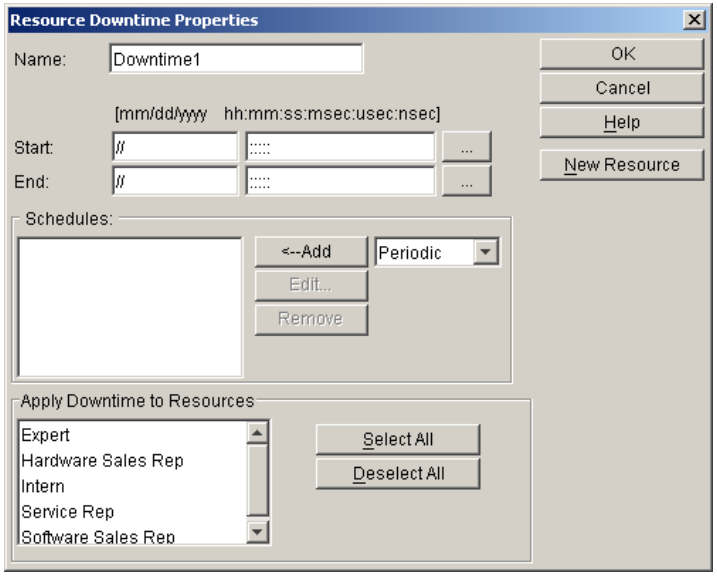


SIMPROCESS comes with three predefined Resource Downtime templates that are listed in the Type combo box on the Resource Downtime list dialog:

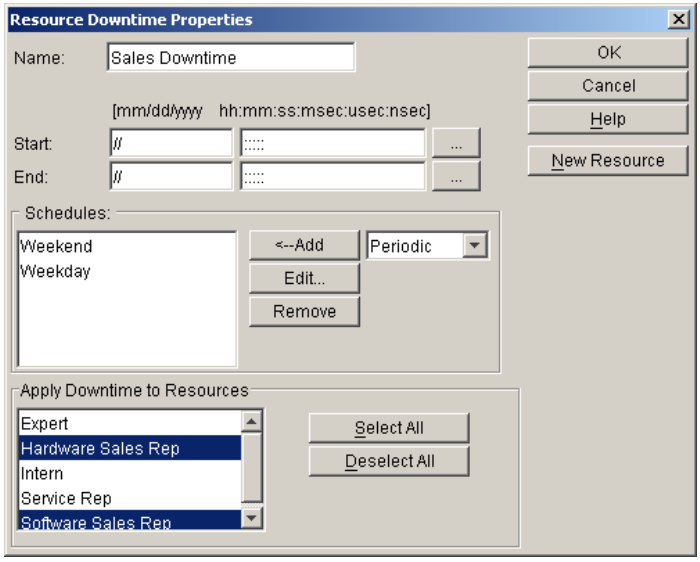
- Empty - Default Resource Downtime, with no Downtime scheduled.
- Night Shift - Includes a Downtime schedule that causes a Resource to only be available from 11 p.m. to 3 a.m. and from 4 a.m. to 8 a.m. Monday through Friday nights.
- Standard Shift - Includes a Downtime schedule that causes a Resource to only be available from 8 a.m. to noon and 1-5 p.m.

The **Add Template** button on the Resource Downtime list dialog creates a Resource Downtime template that can be saved in a library. When the library is loaded the Resource Downtime templates in the library are added to the **Type** list. See "Adding Resource Downtime Templates," beginning on page 206 for more information on creating Resource Downtime templates.

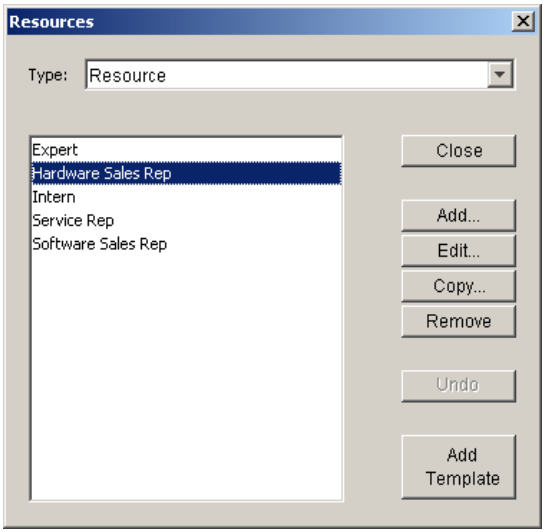
Selecting **Add** brings up a global Resource Downtime dialog.



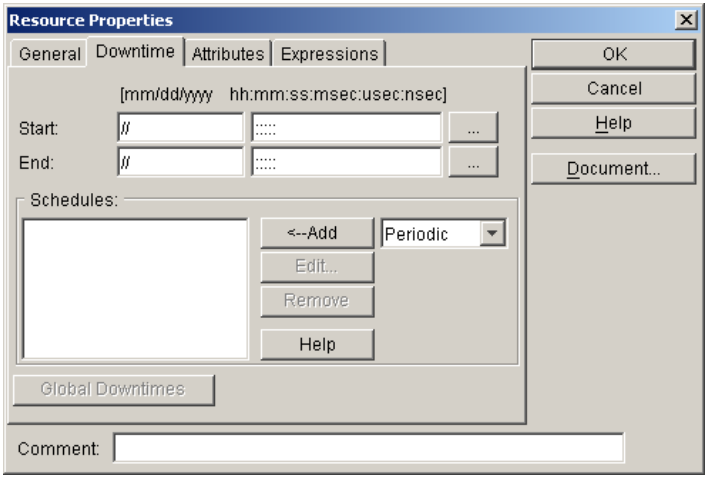
The Downtime's **Schedules** must be defined, and the Resources can be selected that will use this Downtime. Global Resource Downtime properties include a list of the Resources defined in the model. Apply the global Resource Downtime to Resources by selecting the appropriate Resources in the list. Control click to select multiple Resources or click **Select All** to select all the Resources.



Selecting the **New Resource** button displays the dialog that manages the Resources of the model.



Note that when a Resource is edited from the Resource Downtime Properties dialog, the **Global Downtimes** button on the **Downtime** tab is disabled. This is because the global Resource Downtime list is already open. Note that the **Global Downtimes** button will also be disabled when defining a Resource template.



Defining Downtime Schedules of Resources

Global and local Resource Downtimes have the same format. Both consist of **Start** and **End** dates and times and a list of **Schedules**. All schedules in the **Schedule** list are active only between the times specified in the **Start** and **End** fields. If no times are specified, they will default to the **Start** and **End** of the model. It is recommended, unless the modeling scenario requires specific dates, that the **Start** and **End** are left empty. If the **Start** and **End** of the model are changed, then the **Start** and **End** of resource downtimes are changed without having to re-enter the dates and times.

Dialog Field Definitions

- **Start** specifies the earliest time that the resource's downtime schedules are in effect. This field uses a *MM/DD/YY HH:MM:SS:MSS:USS:NSS* format. The millisecond, microsecond, and nanosecond portions may be left blank.
- **End** is the time beyond which the downtime schedules are not applicable. The same date/time format as **Start** is used. After this time, the resource will not go down.
- The **Schedules** list identifies the downtime periods defined for this resource. When a new downtime period is defined, it is added to this list.

Next to the **Add** button for the **Schedule** list box is a combo box containing the available downtime schedule types. There are three basic schedule types: **Periodic**, **Calendar**, and **Usage**. **Calendar** and **Usage** downtime schedules have variations.

A **Periodic** schedule of downtime is one that occurs at intervals of time. The interval may be fixed (every *n* time units) or random (sampled from a statistical distribution).

The **Calendar** schedules are calendar-based, with downtime occurring on particular dates or days of the week, time of day, etc. Types are:

Yearly - Every year, on a particular date and time.

Monthly - A specific day in each month (e.g., 1^{st} of the month).

Weekly - A certain time of day, on the specified day of the week (e.g., Monday, Tuesday...)

Daily - Every day, beginning at the specified time.

Hourly - Every hour, beginning at *n* minutes past the hour.

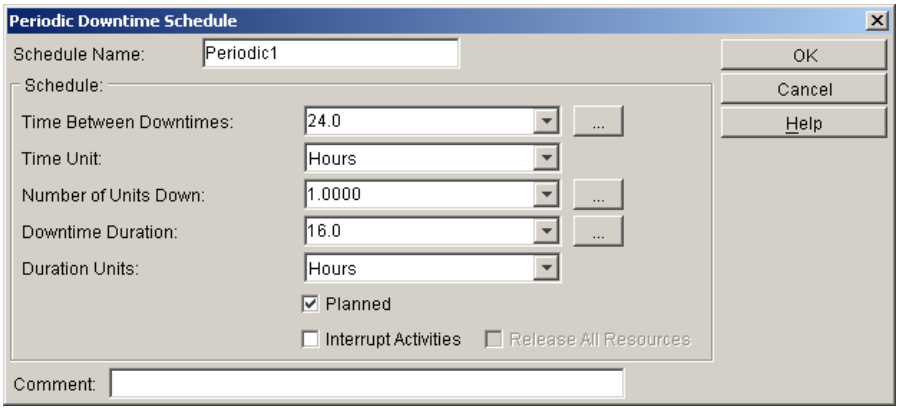
Date - A specific date and time.

There are two types of **Usage** downtime: **Unit Based** and **Time Based**. A **Unit-Based** schedule is based on the number of units of the resource that have been used. The amount of time the units were used is not considered. The **Time-Based** schedule considers the amount of time the resource has been busy.

When adding a new downtime schedule or editing an existing one, a dialog will display that contains the parameters for that downtime schedule type.

The **Downtime Schedule** dialog changes in appearance depending on the **Schedule Type** selected:

- If **Schedule Type** is periodic, the downtime occurs at intervals of time indicated in the **Time Between Downtimes** field. If the **Schedule Type** is calendar, the downtime occurs at the time specified.
- For **Time Between Downtimes** in a Periodic schedule, specify a statistical distribution or constant. For a Calendar schedule, specify a date and/or time.
- If **Schedule Type** is **Weekly,** a list of the days of the week appears. Select a day from this list.



- **Schedule Name** is the name assigned to the downtime period. This name appears in the **Downtime** list box.
- **Time Between Downtimes** defines the time at which the resource becomes unavailable.

  For **Periodic** schedules, this field is labeled **Time Between Downtimes** and contains either a statistical distribution or a constant. If a distribution is specified, the resource will be unavailable at random intervals based on the distribution sampling. If a constant is specified, the resource enters a period of Downtime every *n* time units. For example, to model a dayshift that works from 9 am to 5 pm and is off the rest of the day, specify 24 in this field and select Hours for the **Time Unit**. This means that every 24 hours (i.e., every day at 5 pm) the resource becomes unavailable.

  For **Usage** schedules, this field is labeled **Usage Before Downtime** and contains either a statistical distribution or a constant. Except for the first values, values from statistical distributions are obtained at the end of each downtime. If **Unit Based** is selected for **Usage Type**, **Time Unit** will be disabled. This is because time is not considered for **Unit-Based** downtime. However, units are considered for **Time-Based** downtime. For example, if two units of a resource are in use for the same one-hour period, then the amount of time the resource was in use is two hours (one hour for each unit).

For all other schedules, this field is labeled **Date and Time** or **Time** and contains a date and/or time. Date is specified as a 2-digit month, 2-digit day, and 4-digit year. Time-of-day ranges from 0 to 2400 hours. Downtime of the resource begins at the time specified.

- **Number of Units Down** is the amount of capacity units to be made unavailable. This value can be variable. For instance, if all the capacity of the resource is to go down and an attribute was used for resource capacity, use that same attribute here. That way, when capacity changes, the units down will change as well. Alternatively, using `Evl(Capacity)` for the **Number of Units Down** accomplishes the same thing. If the schedule is a global Downtime schedule that will be used with more than one Resource, always use `Evl(Capacity)` since the Resource capacity can vary from Resource to Resource. See "Evaluate (Evl) Function" on page 235 for a discussion of `Evl`, and see "System Attributes" on page 459 for a description of the Resource System Attribute `Capacity`. **IMPORTANT:** The **Number of Units Down** should not be larger than the number of units defined for the Resource.
- **Downtime Duration** is the length of time that the resource is unavailable. In the above daytime shift example 16 would be specified in this field. **Duration Units** is the time unit that applies to the **Downtime Duration**.
- **Planned** specifies that the period of unavailability is planned. For example, a vacation may be planned, whereas sick time is not planned. If unchecked, then the statistics for downtime display as Unplanned downtime.
- **Interrupt Activities** signals SIMPROCESS to interrupt the processing of any Activities that are currently using this Resource. What happens to the Entities that are processing at an Activity that is interrupted is determined by the resource usage dialog of the Activity. (See "Adding Resource Requirements to Activities" on page 131.) If **Release Entities In Process at Start of Downtime** is not selected at the Activities, Entities using the resource at these Activities have their remaining processing time saved and are placed at the head of the wait queue for the resource. The entity does not leave the Activity and will remain there until all of its processing has completed. (Note that the Get Resource and Free Resource expressions for the Activities interrupted and the resource going down are not executed when the resource is released and re-obtained due to downtime.) When **Release Entities In Process at Start of Downtime** is selected, the entity is released; thus, any other resources obtained at the Activity are released. When an entity's processing is interrupted due to resource downtime, the entity instance expression **Interrupt Processing** for that entity is executed. When the entity re-obtains the resources so processing can continue, the entity's **Resume Processing** entity instance expression is executed. If the **Release Entities In Process at Start of Downtime** has been selected at the Activity, then the **Resume Processing** entity instance expression will not be executed since the entity leaves the Activity. If **Interrupt Activities** is not selected, the selected units of the resource will not go down until the resource has been released. The **Interrupt Activities** option is not available for **Usage** downtime. This is because the downtime is based on usage. Therefore, the check for the start of downtime does not occur until the resource is released.

- **Release All Resources** is only enabled if **Interrupt Activities** has been selected. This option only applies if more than one resource is in use by an entity when a resource interrupts the processing of Activities at downtime. If **Release All Resources** is selected, when the resource goes down all resources in use at that Activity are released. The resource that is scheduled to go down is placed in a down state, and the other resources are available for another entity to use. Note that this applies only to resources assigned at the Activity that is interrupted. If a resource was obtained at another Activity, such as a Get Resource Activity, that resource will not be released. That resource will remain in a busy state during the time the resource that is down remains down. If **Release All Resources** is not selected, none of the other resources in use at the Activity will be released. They will remain in a busy state while the resource that went down remains down. Note that the **Release Entities In Process at Start of Downtime** option on the Activity resource usage dialog overrides the **Release All Resources** option. If the **Release Entities In Process at Start of Downtime** option is selected, the entity is released from the Activity at the start of the downtime, causing the release of all other resources in use by the entity at that Activity.

Note about Release All Resources

Care should be used when selecting this option. If more than one resource is being used at the Activity and one of these resources that has the **Interrupt Activities** option and **Release All Resources** option turned on goes down, several actions occur:

- All resources being used by the entity that were obtained at the Activity are released. This allows the resource going down to go down, and the remaining resources are available for another entity to use.
- The entity is placed at the head of the wait queue for each resource.
- When the resource is available again, the entity attempts to get all the needed resources. If all are available, the entity will continue processing with the remaining time. If the current Activity is the only Activity where the resources that did not go down are used, then all the resources should be reacquired immediately. If not, then it is possible that the resources that did not go down were obtained by an entity at another Activity and are not available. Thus, the entity must wait until the other resources are released.

Creating a Downtime Schedule

To demonstrate the creation of a downtime schedule, some of the periods during which a sales clerk is not available for work will be defined. Note that this is a local Resource Downtime schedule. If multiple resources followed the same downtime schedule, then the Resource Downtime should be defined globally. This downtime will account for:

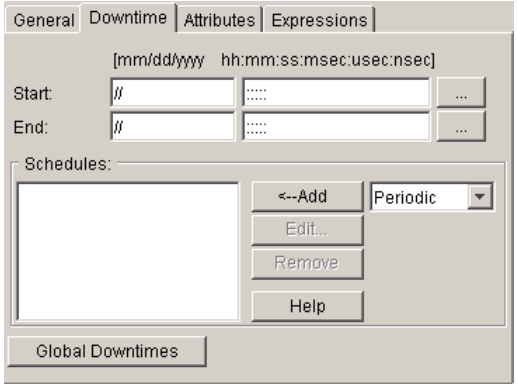
- Daily off-hours (the 16 hours of each 24-hour day that a person is not scheduled to work)
- Weekends
- Sick days.

A complete model would also need to account for lunch hours, vacation time, and unplanned time off (jury duty, personal days, acts of nature, etc.).

For this example, assume that sales clerks operate in two shifts. The first shift, composed of 3 clerks, works from 9 to 5. The second shift, consisting of 2 clerks, works from 2 to 10.

1. If the **Resource** dialog is not already displayed, click on the **Define** menu bar item, and then select **Resources...** Select *Clerks* from the list of resources, and then click on **Edit**.

   Click on **Downtime**.



2. If necessary, set the **Start** and **End** dates. The **Start** and **End** dates are used in conjunction with the **Start Date** and **End Date** of a simulation run (see "Run Settings" on page 77). Normally **Start** and **End** remain empty. When empty, the downtimes will apply to the whole simulation period. For example, if the simulation is scheduled to run for the year 2004, and the downtime should apply only to the month of January, then a **Start** of 1/1/2004 and

an **End** of 2/1/2004 should be entered. Keep in mind that if the simulation run dates are entirely outside of the period defined for the downtime schedule, the downtime schedule will not apply to that simulation.

3. Define the daily hours during which Shift 1 workers *do not* work. Their weekday work shift is from 9 to 5, so they are unavailable from 5:00 p.m. to 9:00 a.m. the following day:

   Schedule Name can be anything. For this example it is *OffShift1*.

   For **Schedule Type**, select **Calendar** and then select **Add**.

   Select **Daily** for **Type**.

   For **Time** (the starting time of the downtime period), enter *17* under HH (1700 hours; 5 p.m.), and *0* under MM and SS. Milliseconds, Microseconds, and Nanoseconds may be left blank.

   In the **Number of Units Down** field, enter the number *3*. This is the number of clerks on Shift 1.

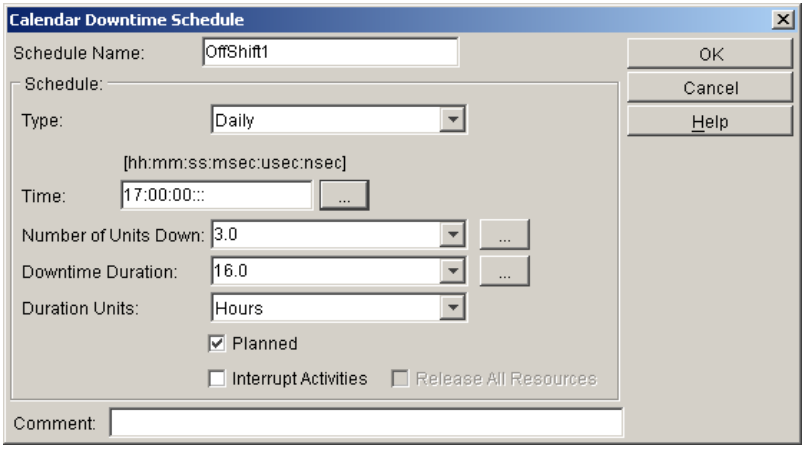
   Remember that the resource **Units** of *Clerks* is 5, so 3 of the 5 will be unavailable during the period being identified.

   Downtime Duration is *16.0*, the number of hours (since the **Duration Units** is set to **Hours**) between the end of one work day and the beginning of the next.

   Unavailability occurs at regularly scheduled times, so select **Planned**.

   Leave **Interrupt Activities** unselected since the clerks finish their current tasks before going down.

   Click on **OK** when the definition is complete; *OffShift1* is added to the **Schedule** list.



4. Define the off-shift period for the two Shift 2 workers. Add another daily downtime schedule. Change **Time** to *22:00*, **Number of Units Down** to *2*, and name the schedule *OffShift2*. Then click on **OK**.
5. Define downtime periods to account for the weekend. Begin with Shift 1:

   For **Schedule Name**, call it *WeekendShift1*.

   Schedule Type is *Calendar*. The **Type** is *Weekly*. A weekend occurs once every week.

   When adding a **Weekly** schedule, a list box with the days of the week appears on the dialog.

   Day of Week is *Saturday*.

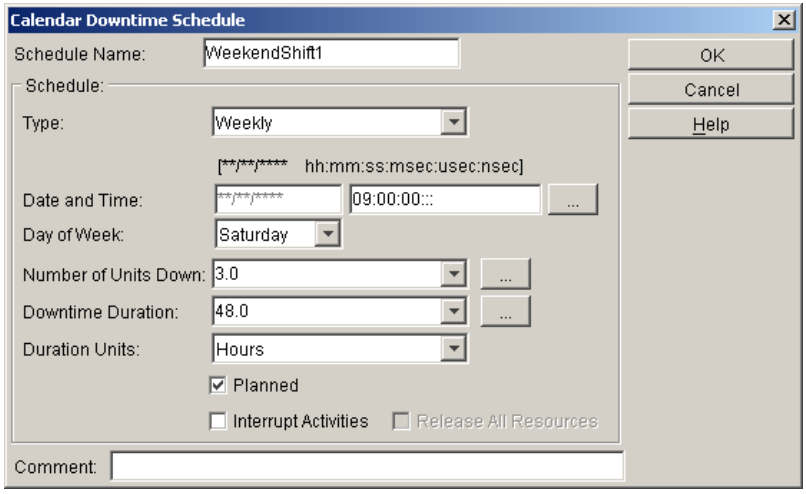
   For **Date and Time**, enter *9* under HH and *0* under MM and SS. Again, Milliseconds, Microseconds, and Nanoseconds may be left blank.

   If a typical weekend begins after work on Friday, remember that the time between 5 p.m. Friday and 9 a.m. Saturday was accounted for in the *OffShift1* period.

   In the **Number of Units Down**, enter the number *3*. This is the number of clerks on Shift 1.

   Downtime Duration is *48.0*.

   Select the **Planned** check box.



   Click on **OK** when finished.
6. **Add** the weekend Downtime period for Shift 2. Change **Downtime** to *14:00*, **Number of Units Down** to *2*, and name the schedule *WeekendShift2*.

7. Finally, time unavailable due to illness will be defined. Illness is more complex to model than weekends or overnights, because it occurs randomly. Random downtime is handled by specifying a frequency distribution instead of a fixed interval of time. Frequency distributions will be introduced here to complete the example.

Defining a Random Downtime

Illness is unplanned. Employees are going to get sick, but when it will happen, who it will happen to, or how long they will be out is unknown. However, reasonable estimates can be made based on past experience.

To define the **Downtime** schedule for sick days:

1. Add a **Periodic Schedule Type**.

   A Periodic schedule is used to describe events that occur at varying intervals of time.

2. **Time between Downtimes** describes the interval period.

   Assume that, in a typical month, one of the five employees comprising the *Clerks* group will be out sick for a period of time. Moreover, assume that while a month is typical, the time between bouts of illness can be as little as three days or as much as a year. To reflect this, specify a triangular distribution:

   Click on the arrow next to the **Time Between Downtimes** field to display a list of statistical distributions.

   Scroll through the list to the default definition for **Triangular** distributions. It reads:

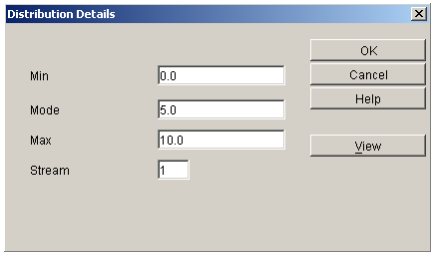
   ```
   Tri(0.0,5.0,10,0)
   ```

   There are three parameters in this definition: **Minimum** value, most frequent value (**Mode**), and **Maximum** value. Values are in the **Time Unit** selected.

   Select **Tri...** from the list.

   Click on the box to the right of the arrowhead next to the **Time Between Downtimes** field.

   This displays a dialog for defining the parameters of the distribution:

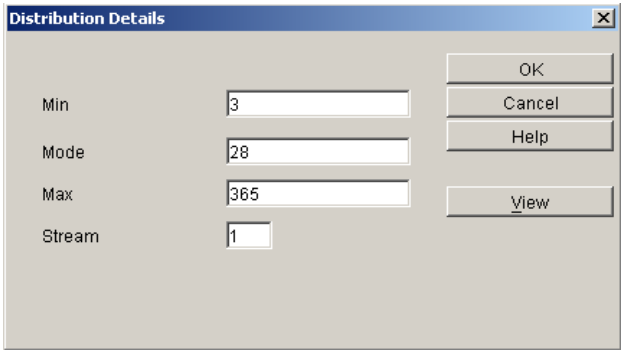


The following assumptions have been made:

Typically, there is a clerk out sick every 28 days. This is the most likely estimate.

The minimum period between illnesses is 3 days.

The maximum period between illnesses is 1 year (365 days).



Click on **OK**.

3. Set **Time Unit** to *Days*.
4. Set **Units Down** to *1*.

   The **Units** (number of clerks) of this resource is 5. The frequency of downtime applies to one clerk at a time, not all five.

5. **Downtime Duration** is another variable, random event.

For this model, assume that a clerk is unavailable for at least 24 hours (one sick day), and no more than 10 days at a time, with most absences lasting two days. Following the procedure described in step 2, define a triangular distribution with these parameters:

6. Select *Days* for **Duration Unit**.
7. Set the **Schedule Name** to *SickTime*.
8. The downtime is not planned, so leave the **Planned** check box blank.
9. Leave **Interrupt Activities** unselected.
10. Click on **OK** to add the definition to the **Schedule** list.

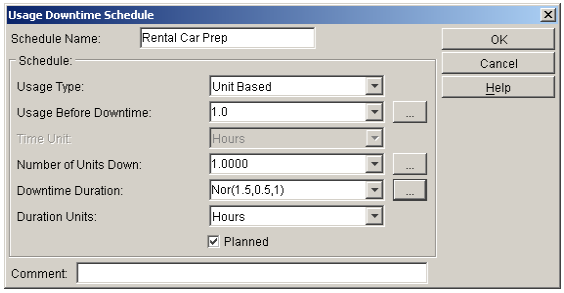
Click on **OK** to accept the entire **Downtime Schedule**.

Defining a Usage Downtime

Sometimes a resource should be unavailable after use. As an example, consider the scenario where the resource is a rental car. When the rental car is released after use, the resource must be unavailable for some time to represent the time required to clean, maintain, and refuel the car. A **Unit Based Usage** downtime schedule can model this scenario.

To define the **Downtime** schedule for rental car usage:

1. Add a **Usage Schedule Type**.
2. Select **Unit Based** for **Usage Type**.
3. **Usage Before Downtime** sets the number of units that must be used before downtime occurs. The arrow next to the **Usage Before Downtimes** field displays a list of statistical distributions. No change is needed since the default of 1.0 is correct. This means every unit of the rental car resource will go down for a period of time when released.
4. Set **Number of Units Down** to 1.0.
5. Select the Normal distribution (`Nor`) for **Downtime Duration**. The **Downtime Duration** represents the time required to prepare the rental car for another use. Enter 1.5 for the Mean and 0.5 for the Std Dev.
6. Leave the **Duration Units** at the default value (Hours).



Modifying a Downtime Schedule

Removing existing **Schedule** items from a **Downtime Schedule** is simple: open the global or local **Downtime Schedule**, highlight the **Schedule** item to delete, and click on **Remove**.

To change a **Schedule** item, select it from the **Schedule** list, click on **Edit,** and then modify the parameters on the **Downtime Schedule** dialog. Click on **OK** to accept the changes.

The **Add** button updates the **Schedule** list box to include the schedule just defined.

The **OK** button finalizes the changes made to the **Downtime Schedule**.

The **Cancel** button exits the **Downtime Schedule** dialog without accepting any schedule changes made.

Event Logs

Time Stamps and Recorders are event logs supported in SIMPROCESS.

Time Stamping is a facility that SIMPROCESS offers for monitoring times between any two events. For example, start to finish time. The three steps for using Time Stamps are:

- Defining Time Stamps
- Adding Entry/Exit Event Logs to Processes/Activities
- Viewing Time Stamp Reports

Defining Time Stamps

A Time Stamp can be thought of as a label or key that contains the current simulation time. This key is added to an entity by an Event Log when it either enters or leaves a Process or Activity. Pairs of keys can be specified and Entity cycle times can be computed between them.

Time Stamping can be performed upon entry (and/or) exit from an Activity. Time Stamp specifications can be defined between two stamp keys, enabling the monitoring of cycle time & counts between two Time Stamps.

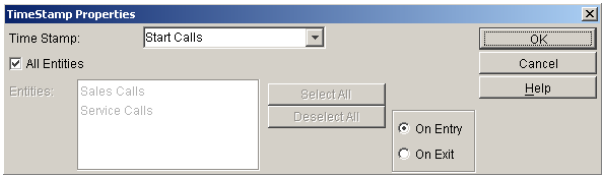
1. Select **Time Stamps...** from the **Define** pull-down menu.
2. Select **Add** to define **Time Stamp** requirements.
3. Define **Start** and **Stop** keys, select the whether or not to **Collect Statistics** (results available in Standard Report), and select plot options (**Real-Time Trace Plot**, **Real-Time Histogram Plot**).
4. The **Set Plot Properties** button brings up a plot properties dialog for each plot selected. See “Setting Plot Properties” on page 178.
5. Define as many **Start** and **End** keys as desired. Press the **Close** button when finished.

Entry and Exit Event Logs to Processes/Activities

Once **Time Stamp**s have been defined, specify the Process or Activity where they will be attached to the Entity. The **Time Stamp** can be added to the Entity upon entry into and/or exit from the Process/Activity. Time stamps are then added to Entities that traverse this process during simulation execution. To add a time stamp:

1. A **Time Stamp** must first be defined using the procedures starting on page 309.
2. Using an **Activities/Process Properties** dialog, select the **Event Logs** tab.

3. Using the **Type** combo box, select **Time Stamp** and press the **Add** button. The **Time Stamp Properties** dialog appears, as shown below.



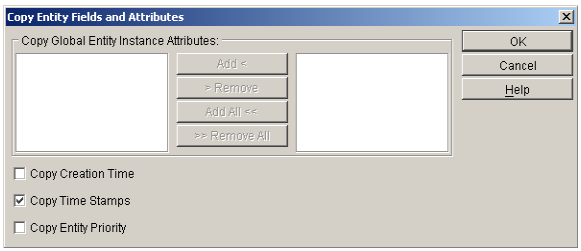
4. Select either one or more individual **Entities** or a range of **Entities** from the list box. Check the **All Entities** box to stamp every entity in the model.
5. Choose either the **On Entry** or **On Exit** check boxes for the **Time Stamp**.
6. Select a **Time Stamp Key** in the combo box which contains the predefined time stamp labels.
7. Press the **OK** command button and notice the **Time Stamp** report name in the **Event Logs** list box.

Passing Time Stamps Between Entities

When an entity enters a Clone, Split, or Transform Activity, a new instance of an entity type leaves that Activity. The Original entity, when it leaves a Clone or Split Activity, will continue to carry Time Stamps that were defined upstream on the entity. The Clone Entities will not, by default, carry those Time Stamps defined on the Original entity. Clone Entities can also inherit the Time Stamps of the Original entity.

On the **Properties** dialog of the Clone Activity, simply click on the **Copy Time Stamps** check box. This will cause each instance of the Clone Entities to carry the Time Stamp information inherited from the Original entity.

To specify that the Clone Entities resulting from a Split Activity inherit Time Stamp information from the Original entity, edit the **Properties** of the connector(s) emanating from the Clone pad. Now, click on the **Copy Attributes** button. This will open the **Copy Entity Fields and Attributes** dialog. This dialog contains the same **Copy Time Stamps** check box described above.



The **Properties** dialog of the Transform Activity has a **Copy Attributes** tab that works the same as the dialog from the **Copy Attributes** button on the Split connector.

When an entity carrying a Time Stamp is Batched or Assembled, the output entity will not be aware of the Time Stamp. The output entity must be unbatched in order to register the endpoint of the Time Stamp (to do this for an Assembled entity, turn on the **Batch Component Entities** check box on the **Properties** dialog of the Assemble Activity).

Differences Between Time Stamps and Recorder Objects

Time Stamps measure time delays during a simulation. How much time an entity spends at one or more Processes/Activities is captured using Time Stamp keys.

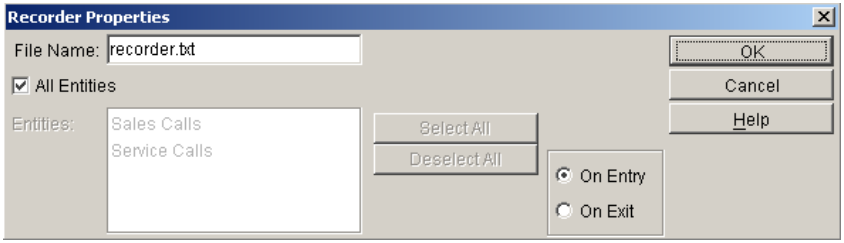
Recorder Objects measure arrival/departure rates at Processes/Activities by recording how many Entities arrive/depart a Process/Activity over time. The time between arrivals and departures can also be calculated using Recorders.

Recorders

In addition to Time Stamps, Recorders will write the arrival or departure time of an entity at a Process/Activity into a file called `recorder.txt`. The file can be examined after the simulation to observe the actual times a specific Entity arrived or departed from specific Processes/Activities.

1. Using an **Activities/Process Properties** dialog, press the **Event Logs** tab. The **Event Logs** tab lists the currently defined **Time Stamp**s and **Recorder** objects (either **On Entry** or **On Exit**).

2. Using the **Type** combo box, select **Recorder** and choose the **Add** button. The **Recorder Properties** dialog appears, as shown below.



3. Choose to record arrival times (**On Entry**) or departing times (**On Exit**) of the **Entities** in this Process/Activity.

4. Select the Entities to record. If the **All Entities** check box above the list box is selected, all Entities in the list box will be recorded
5. Choose **OK** to leave the dialog when finished entering data, confirming the current selections. The **Cancel** button rejects the current dialog selections.
6. The **Event Logs** tab shows the defined **Recorders** (either **On Entry** or **On Exit**) along with current **Time Stamps**.

Part C
Advanced SIMPROCESS Tools

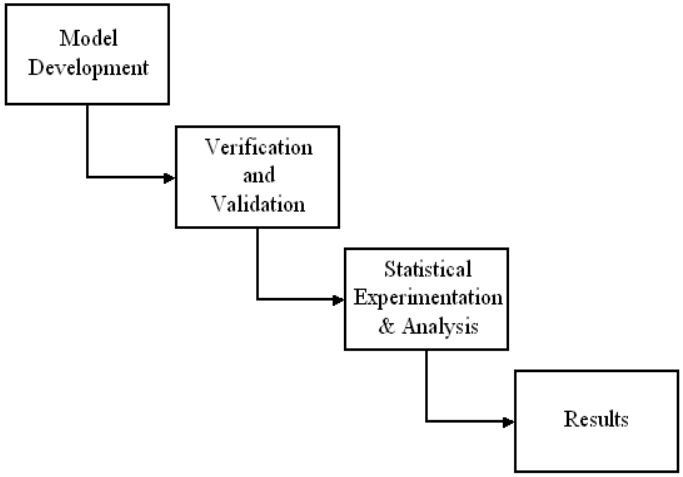
The chapters in this section describe the advanced tools and the database included with SIMPROCESS Professional.

CHAPTER 12

Advanced Data Analysis

SIMPROCESS comes with a data analysis tool that extends the ability to conduct statistical data analysis: ExpertFit. The ExpertFit tool:

- Increases the accuracy of experiments
- Decreases the time to find the solution to the problem
- Provides a statistical software tool tailored to the statistical simulation environment
- Provides a unique graphical user interface
- Performs data analysis
- Models random processes



ExpertFit is used to analyze data and construct a data model of the random process that generated the data. An introduction to the statistical background for data analysis and data modeling is provided in the following paragraph, “An Introduction to Data Analysis and Modeling.”

An Introduction to Data Analysis and Modeling

Introduction

Probability distributions are a way of describing the random variations that occur in the real world. Although the variations are called random, there are different degrees of randomness, and the different distributions correspond to how the variations occur. Consequently, different distributions are used for different purposes.

Probability distributions are represented by probability density functions. Probability density functions show how likely a certain value is. The more likely the value, the larger the probability density function at that point. The total probability at all points should sum to 100%, so the area under a probability density function is equal to one.

Cumulative density functions give the probability of selecting a number at or below that value. For example, if the cumulative density function value at 1.7 was equal to .75, then 75% of the time, selecting from that distribution would give a number less than 1.7. The value of a cumulative density function at a point is the area under the corresponding probability density curve to the left of that value. Since the total area under the probability density function curve is equal to one, a move towards more positive values in a cumulative density function approaches one.

Knowledge of all these details is not needed to effectively model a situation. Knowing which distribution best fits the data is most important. The curve fitting capabilities of ExpertFit make it easy to find the correct distribution for data.

In addition, standard distributions can be examined visually for different combinations of input parameters.

Standard Statistical Indicators

There are several statistical indicators that can tell a lot about the distribution of random values. Consult an introductory statistics textbook for detailed discussions of these indicators. This section simply gives their meanings and some of their implications. More definitions can be found in the "Statistical Tools Glossary," beginning on page 452 at the end of this manual.

The mean is the most important characteristic of a data sample. Always try to get a good value for the mean (from actual data, if possible) if the scenario represents a time to complete some task or the number of arrivals in a certain time period.

The mode is the most likely value in a set of data. Consider the following list of numbers:

2, 3, 3, 3, 9, 10

The mode for this set of data is 3, since it occurs most frequently. The mean for this set of data is 5. If a distribution is symmetric about the mean, and singly-peaked, then the mode and the mean will be equal. In this case, the distribution contains a couple of large values which shift the mean away from the mode.

As discussed later, the mode is an important parameter for specifying a triangular distribution.

The standard deviation is a simple measure of the spread in the data. It is calculated by finding the mean, summing the squares of all the differences between the mean and the data points, taking the square root of this value, and then dividing by the square root of the number of data points. Loosely, it is the average difference from the mean. Why are the square and square root are taken? Because the result would be zero if just the differences were summed!

The standard deviation is a measure of how much spread there is in the data. If the standard deviation is large, there is a wide variation in the data. If it is small, the data are tightly clustered around the mean. The standard deviation is a necessary piece of information for many standard distributions. The variance is the standard deviation squared.

Most of the parameters for continuous distributions can be classified, on the basis of their physical or geometric interpretation, as being one of three basic types: location, scale, or shape parameters. The following discussion is taken from the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000).

> A location parameter l specifies an abscissa (x axis) location point of a distribution's range of values; usually, l is the midpoint (e.g., the mean of a normal distribution) or lower endpoint (e.g., location for a Pearson type V distribution) of the distribution's range. As l changes, the associated distribution merely shifts left or right without otherwise changing. Also, if the distribution of the random variable X has a location parameter of 0, then the distribution of the random variable $Y = X + l$ has a location parameter of l.
>
> A scale parameter b determines the scale (or unit) of measurement of the values in the range of the distribution. (The standard deviation is a scale parameter for the normal distribution.) A change in b compresses or expands the associated distribution without altering its basic form. Also, if the random variable X has a scale parameter of 1, the distribution of the random variable $Y = bX$ has a scale parameter of b.
>
> A shape parameter a determines, distinct from location and scale, the basic form or shape of a distribution with the general family of distributions of interest. A change in a generally alters a distribution's properties (e.g., skewness) more fundamentally than a change in location or scale. Some distributions (e.g., exponential and normal) do not have a shape parameter, while others (e.g., beta and Pearson type VI) may have two.

A probability density function is a representation of a statistical distribution. The probability density

function is large for likely values sampled from a distribution and is small for unlikely values. The maximum value for the probability density function is equal to the mode for that distribution. The area under the probability density function curve within a certain range of values gives the probability of sampling from that distribution and getting a number within that range. Of course, the total area under the curve must be equal to one, since a number from the distribution must be less than or equal to one.

A confidence interval is the range of values a certain percentage of the population would be expected to fall into if the sample were drawn from a normal distribution. Plus or minus one standard deviation corresponds to about a 68% confidence interval; plus or minus two standard deviations corresponds to about a 95% confidence interval; and plus or minus three standard deviations corresponds to about a 99.7% confidence interval.

Why Statistical Simulation Experiments?

Mean-Value Analysis

Mean-value analysis is a simple, although often quite useful, approach to modeling. The basic philosophy is to model processes by their average output.

For example, suppose there is a station that can process five parts per hour, and on average four parts arrive every hour. Mean-value analysis shows that the station should be able to handle the expected load.

However, in the real world there might be some hours the station may process only three parts, and other hours it may process seven. Likewise, there may not be a perfectly steady flow of four parts into the station every hour. Sometimes there may be more and sometimes less.

This statistical nature of the real world will lead to a diminished throughput, for there will be times when the station is idle, and other times when it is backed up, disrupting the flow to and from it in the rest of the factory. This is the limitation of mean-value analysis, and the reason that simulation is necessary for accurate predictions.

The Importance of Experimental Data

It is very important to have experimental data as the basis of a model. This may seem like a paradox: If I am modeling something that does not exist, where will I get the experimental data?

This is not as big a problem as it sounds. The individual components of a similar existing system will probably be close enough to ones in the proposed system to be useful in the model. The data do not have to be exhaustive, *any data is much better than no data*.

In fact, a good test of the model building process is to build a model of an existing system and check how closely the model and the system match up. This can often be a key to convincing others of the validity of the simulation modeling approach.

SIMPROCESS Statistical Distributions

The following table contains the statistical distributions available in SIMPROCESS. Other distributions can be created from these using the Define Distributions function. See "Statistical Distributions" on page 425 for descriptions of each distribution.

Beta Distribution	**Bet(shape1, shape2, minimum, maximum, stream)**
Binomial Distribution	**Bin(trials, probability, stream)**
Erlang Distribution	**Erl(mean, shape, stream)**
Exponential Distribution	**Exp(mean, stream)**
Gamma Distribution	**Gam(mean, shape, stream)**
Geometric Distribution	**Geo(probability, stream)**
Hyper Exponential Distribution	**Hex(mean1, mean2, probability1, stream)**
Inverse Gaussian Distribution	**InG(location, scale, shape, stream)**
Inverted Weibull Distribution	**InW(location, scale, shape, stream)**
Uniform Integer Distribution	**Int(minimum, maximum, stream)**
Johnson S_B Distribution	**JSB(minimum, maximum, shape1, shape2, stream)**
Johnson S_U Distribution	**JSU(location, scale, shape1, shape2, stream)**
Log-Logistic Distribution	**LLg(location, scale, shape, stream)**
Log-Laplace Distribution	**LLp(location, scale, shape, stream)**
Lognormal Distribution	**Log(mean, standard deviation, stream)**
Negative Binomial Distribution	**NgB(s, probability, stream)**
Normal Distribution (non-negative)	**Nor(mean, standard deviation, stream)**
Normal Distribution (unbounded)	**Nrm(mean, standard deviation, stream)**
Pareto Distribution	**Par(location, shape, stream)**
Poisson Distribution	**Poi(mean, stream)**

Pearson Type V Distribution	**PT5(location, scale, shape, stream)**
Pearson Type VI Distribution	**PT6(location, scale, shape1, shape2, stream)**
Random Walk Distribution	**RnW(location, scale, shape, stream)**
Triangular Distribution	**Tri(minimum, mode, maximum)**
Uniform Distribution	**Uni(minimum, maximum, stream)**
Weibull Distribution	**Wei(shape, scale, stream)**

CHAPTER 13

SIMPROCESS Database

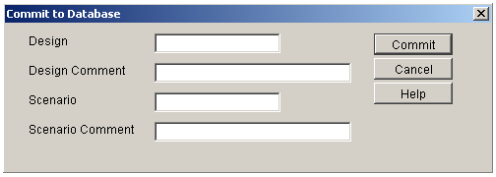
The Windows version of SIMPROCESS includes a Microsoft Access 2000 database (SimProcDB.mdb) designed to hold simulation results from simulation runs. This database includes predefined queries, graphs (forms), and reports, each of which can be modified to tailor the database for output analysis. The procedures for connecting the database to SIMPROCESS using ODBC are explained in the Getting Started Manual. (An Access 97 database is available upon request.)

SIMPROCESS can use other non-Access SQL databases by making appropriate entries in the `sProcDB.properties` file provided by the installer. This file is installed on both Windows and non-Windows systems and is pre configured for use with the Access database described above. Additional information is included in this chapter to aid in using a non-Access SQL database patterned after the Access database (SimProcDB.mdb) to hold simulation results.

Note that the discussion in this chapter is only concerned with storing simulation results in SimProcDB.mdb or in a user-created SQL database patterned after SimProcDB.mdb. There are expression statements that allow SIMPROCESS to read from or write to any SQL database. See "Interfacing With A Database" on page 260 for more information.

Committing Results to the Database

To commit simulation results to the database, select **Commit to Database** from the **Report** menu. The menu item will not be enabled until a simulation run is complete (either terminating normally or user terminated). If the database is not found, an error dialog will appear. If this occurs, recheck the database connection through the ODBC control panel if using the Access database, or recheck the values in the `sProcDB.properties` file. Normally, the **Commit To Database** dialog will appear. A design name and scenario name must be entered. The design and scenario comments are optional. What constitutes a design will be discussed in the next section.



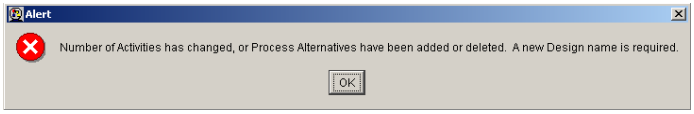
Once the information has been entered, click on **Commit**. At this point SIMPROCESS verifies that the design name and scenario name are allowable. If so, the results are stored in the database. When finished, the status bar shows **Commit Complete**.

System, Design, and Scenario

Three tables in the database control the results placed there: **System**, **Design**, and **Scenario**. The **System** table is the highest level table and contains the model name. Therefore, the database is designed to hold results from more than one model. If a record is deleted from the **System** table, all records related to that model are deleted from the Access database. (In order for this to be true in another SQL database, the appropriate relationships and/or constraints must be established when the database is created.) The **Design** table holds data from different versions of the same model. A model design consists of the following:

- Number of entity types
- Entity type names
- Number of resources
- Resource names
- Resource costs
- Number of Activities, Processes, and Process alternatives
- Names of Activities, Processes, and Process alternatives
- Activity/Process structure
- Start and End date
- Start and End time
- Number of replications
- Output time units.

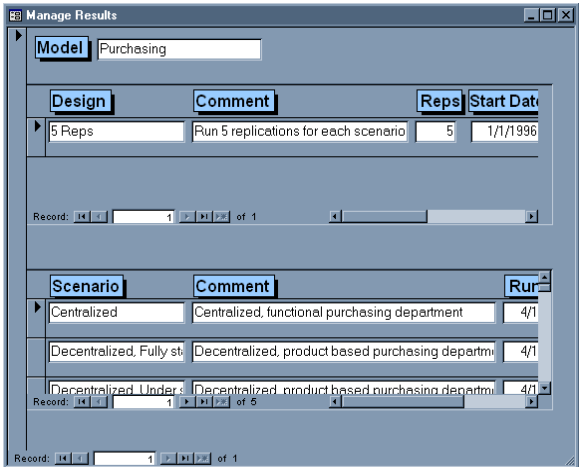
If any of the above change, then a new design name is required. For instance, assume results have been committed to the database with a design name of *Design 1*. After that a Process alternative is added to the model and the model is run again. If the same design name as before is used, SIMPROCESS will prompt for a new design name because the number and names of Process alternatives have changed.


Alert
Number of Activities has changed, or Process Alternatives have been added or deleted. A new Design name is required.
OK

Note that there will be no prompt for a new design name if a different alternative is run that was already in the model. If another alternative is run, the design name or scenario name can be changed. When a design is deleted from the **Design** table, all records associated with that design are removed from the Access database. (In order for this to be true in another SQL database, appropriate relationships and/or constraints must be established when the database is created.) Therefore, to reuse a design name for the same model name (and there has been a design change), first delete the design.

A scenario is used to track various runs of the same system (model) and design. For example, one run might have a certain resource level at 3 while another run has the same resource level at 4. Differentiating those runs in the database is done through the scenario name. The scenario comment field is a good place to document the important settings for that scenario. Again, if a scenario is deleted, all records associated with that scenario will be deleted from the Access database. (As before, in order for this to be true in another SQL database, appropriate relationships and/or constraints must be established when the database is created.)

In the Access database, the **Manage Results** form should be used to delete results for a Model (System), Design, or Scenario. DO NOT modify the tables directly. Using the **Manage Results** form ensures the tables do not become corrupted. This form can be run from the **Forms** tab in Access. Also, when using **Launch Database Application** from the **Report** menu, the **Manage Results** form launches automatically. If the form is blank, then there are no run results in the database.

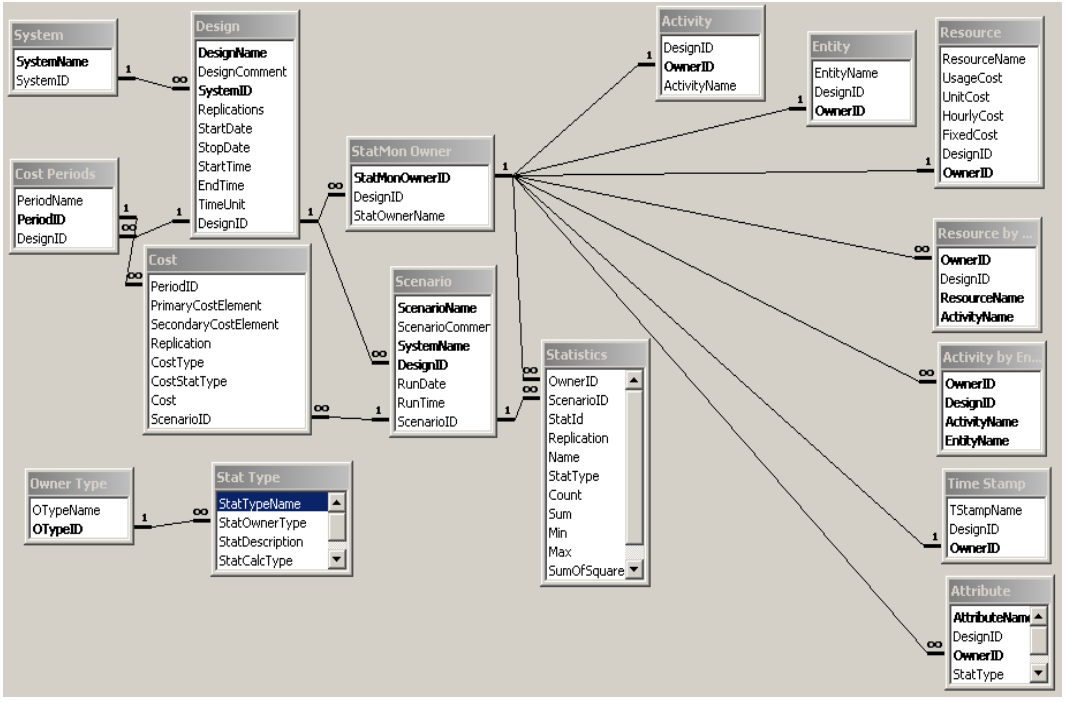


The **Launch Database Application** menu item is only enabled on Windows systems. It will be enabled even if the sProcDB.properties file is configured for a non-Access database.

IMPORTANT: It is good practice to regularly compact the Access database, particularly after deleting records. This can be done from the **Tools** menu of Access by choosing **Database Utilities**.

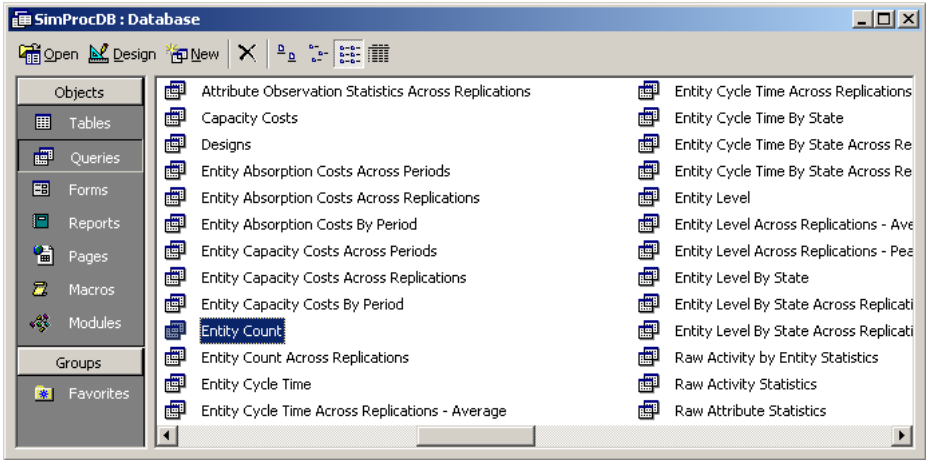
Database Table Relationships

Select **Relationships...** from the **Tools** menu in Access to view all the tables and the relationships between them in the Access database.This is helpful in understanding how the queries were constructed. Because other database tools may or may not support constraints and relationships in the same way as Access, it will be up to the user to create comparable mechanisms there if desired.

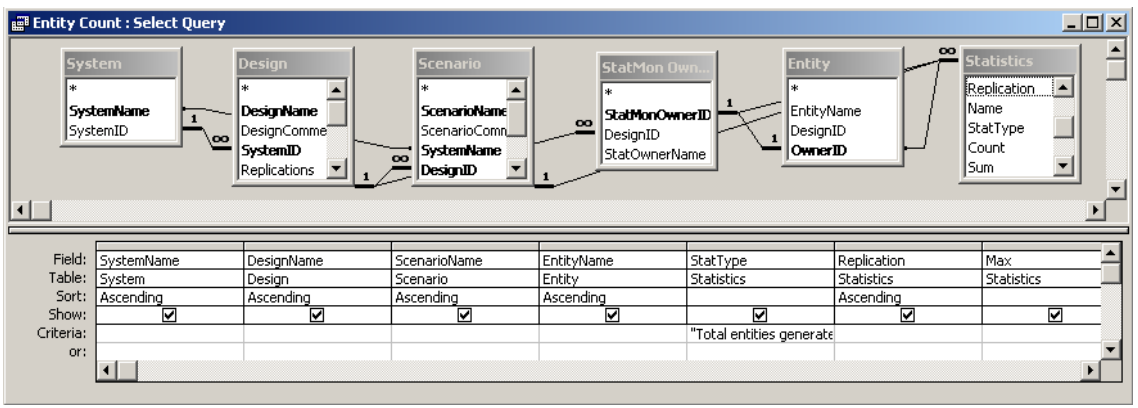


Database Queries

The predefined queries in the SIMPROCESS Access database are designed to offer the same information provided in the Standard Report. (See “Standard Report” on page 163.) The queries can be used as-is or copied and modified. The queries are not restricted by system, design, or scenario. So when the **Entity Cycle Time** query is run, all entity cycle times without restriction will be displayed. Copying a query and restricting its search is one example of tailoring a query for analysis.

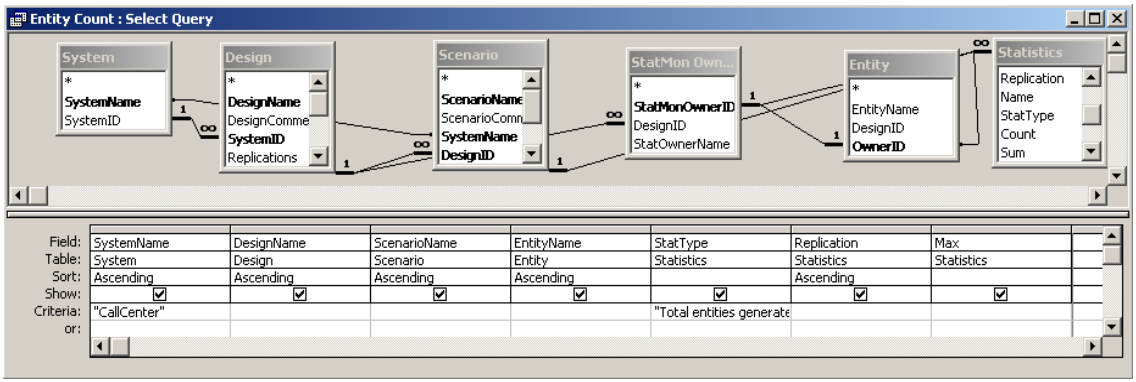


All of the queries were created in Access’ Design View rather than SQL. Shown below is the Design View of the **Entity Count** query.

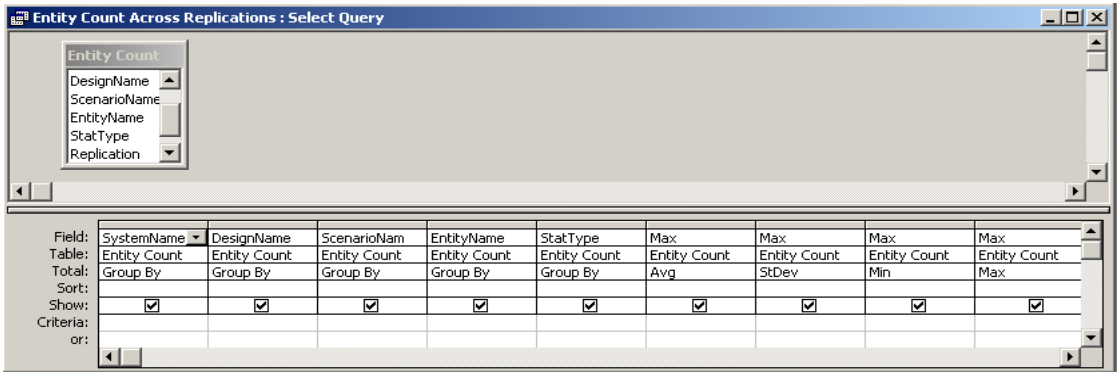


Even though the whole criteria cannot be seen, note that the **StatType** field from the **Statistics** table is

restricted by "Total Entities generated" or "Entities remaining in system" or "Total Entities disposed." These are the statistics types that make up **Entity Count**. Other fields could be restricted as well. For instance, the **SystemName** field from the **System** table could be restricted so only one model's results would be available. In the example below the query to the demonstration model **CallCenter** is restricted by placing "CallCenter" in the **Criteria** row of the query under **SystemName**.



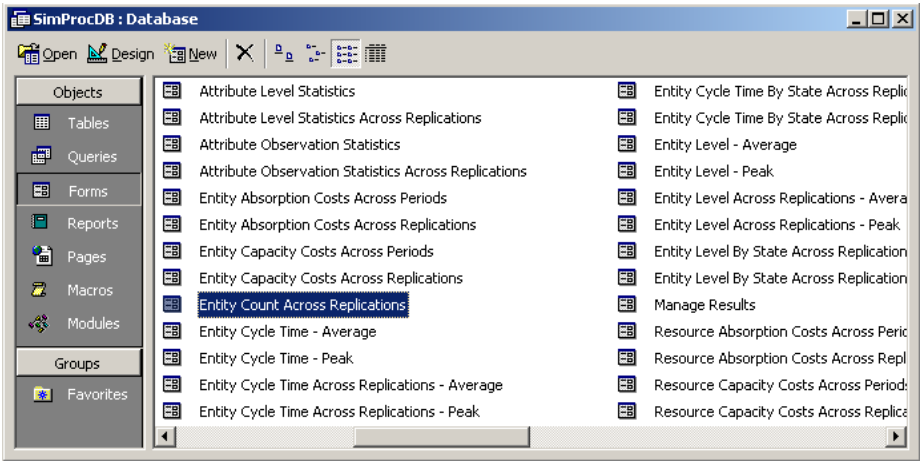
The queries that generate results across replications were developed using the queries that give results by replication. So if the **Entity Count** query is restricted to **CallCenter**, then the **Entity Count Across Replications** query will also be restricted to **CallCenter**. Looking at the Design View for **Entity Count Across Replications**, the only data source for the query is the **Entity Count** query.

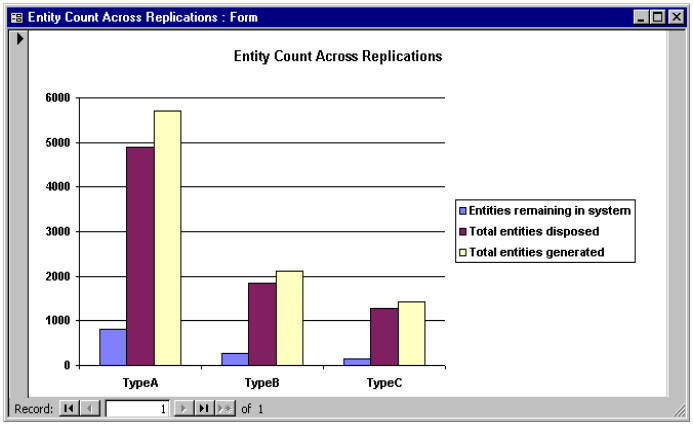

Entity Count Across Replications : Select Query
Entity Count
DesignName
ScenarioName
EntityName
StatType
Replication
Field: SystemName DesignName ScenarioNam EntityName StatType Max Max Max Max
Table: Entity Count Entity Count Entity Count Entity Count Entity Count Entity Count Entity Count Entity Count Entity Count
Total: Group By Group By Group By Group By Group By Avg StDev Min Max
Sort:
Show:
Criteria:
or:

The average, standard deviation, minimum, and maximum were determined by selecting the appropriate statistic in the **Total** row for the field from the **Entity Count** query that was to be summarized across replications. This was accomplished by not including the **Replication** field from the **Entity Count** query.

Forms (Graphs) and Reports

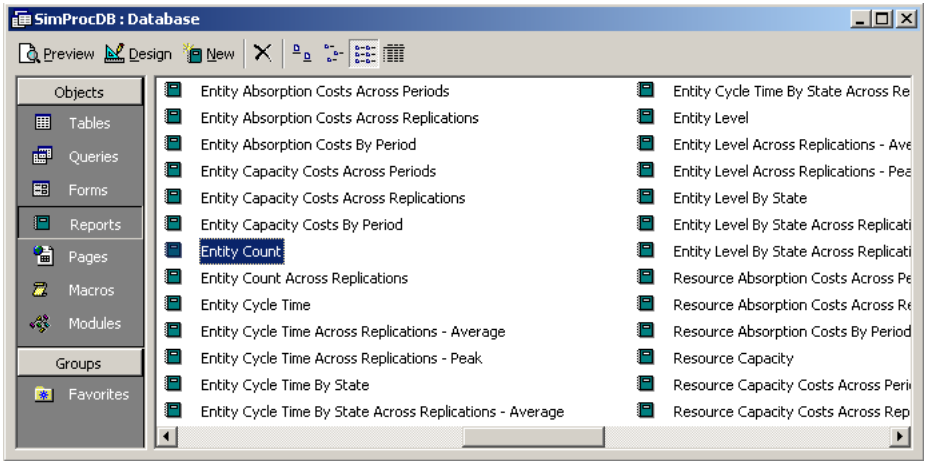
The **Forms** tab contains the predefined graphs plus the **Manage Results** form. These graphs are based on the predefined queries. Therefore, the **Entity Count Across Replications** form (or graph) is based on the **Entity Count Across Replications** query. In order to restrict the graph to only certain records, go to the original query (in this case **Entity Count** since **Entity Count Across Replications** is based on it) and restrict it.





The **Reports** tab contains the predefined reports. Like the graphs, the reports are based on the predefined queries. Therefore, the **Entity Count** report is based on the **Entity Count** query. In order to restrict the

report to only certain records, go to the original query (in this case **Entity Count**) and restrict it.

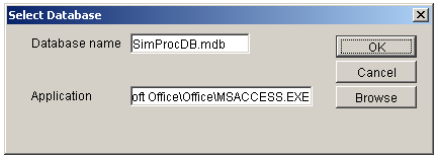


When using a non-Access SQL database, the predefined queries, graphs and reports described in this chapter may serve as a basis for developing SQL statements for retrieving and analyzing database contents. Those using SIMPROCESS on non-Windows systems where the SimProcDB.mdb file is not installed may obtain a copy for reference at the SIMPROCESS web site, or contact SIMPROCESS Technical Support for assistance.

Launch Database Application

This menu item on the **Report** menu (only enabled on Windows systems) brings up a dialog that selects the database and database application to use. SimProcDB.mdb and Microsoft Access are the defaults. (The remaining portion of these instructions assume MS Access is the database application.) If the database field is blank, then Access will start and prompt to open a database. If only a database is in the field (with no path), SIMPROCESS assumes the database is in the `SPUser` directory. If this is not the case, Access will start and prompt for a database. When the database desired is not in `SPUser`, enter the full path, and Access will open with that database.

If SimProcDB.mdb is entered in the database name field, the **Manage Results** form will launch automatically when the database opens. If other actions are desired, simply close the form and continue. Always use the **Manage Results** form to delete records from SimProcDB. If the tables are edited directly, they could become corrupted and run results placed in the database would be lost. The **Manage Results** form can be launched from the **Forms** tab. Copies of SimProcDB.mdb may be used for results. However, the **Manage Results** form will not launch automatically.



SIMPROCESS and Other Databases

Most of this chapter assumes the use of the Microsoft Access database with SIMPROCESS. Those not using Windows will be compelled to use another database, and Windows users may wish to have the flexibility to do so. This section will provide information which those users must know to employ another database for analyzing results.

To store results in any database, SIMPROCESS must have the file `sProcDB.properties` in the `SPUser` directory. The one provided by the installer is configured for use with the Access database. Also included there are two example files which can aid in using another SQL database:

- `mysql.sProcDB.properties`
- `simprocessdb.sql`

The `mysql.sProcDB.properties` file is an example of what needs to be put into the `sProcDB.properties` file in order to use MySQL, a popular open source database, with SIMPROCESS. It contains two required properties and others that are commented.

- `jdbc.drivers` - This property must provide the fully qualified name of a Java class which is a JDBC driver compatible with the database to be used. The one in this example is from the **MySQL Connector/J** driver, available with MySQL at www.mysql.com. The driver must be in the SIMPROCESS classpath at runtime, so the jar file containing it should be placed into the `jre/lib/ext` directory under the SIMPROCESS installation directory.
- `jdbc.url` - This property identifies a specific database and is used to connect to it via the driver named above. Details on the possible forms and values of this property will be documented with available Java JDBC drivers. It is important to note, however, that SIMPROCESS will assume that any value beginning with "jdbc:odbc" is the Access database. The example in this file shows using a MySQL database named "simprocess" on the local system.
- `jdbc.username` - This property is disabled in the example. If the database configuration requires a user name, remove the "#" to enable the property and give it an appropriate value.
- `jdbc.password` - This property is disabled in the example. If the database configuration requires a user password, remove the "#" to enable the property and give it an appropriate value.

The `simprocessdb.sql` file is an example of Data Definition Language (DDL) for creating a database in MySQL that is suitable for use with SIMPROCESS. The file contains necessary DDL statements to drop and create a database named "simprocess" and then to create each of the tables needed for storing simulation results, some of which require insertion of static data. While the Access database contains some tables and/or columns with spaces in their names, this DDL uses underscore characters instead. When the value of the `jdbc.url` property does not begin with "jdbc:odbc", SIMPROCESS will use these names to allow support for the widest range of SQL databases. Other features, such as foreign keys, referential integrity, cascading deletes, etc., are not supported by all databases, a fact which should be considered in the management of any selected SQL database.

The DDL statements in this example name the database tables and columns using the same case that

SIMPROCESS uses in its internal SQL statements, though not all databases will require or respect case. For instance, testing showed that MySQL server 3.23.52 insisted that table names in SQL statements match the case used in the DDL, while MySQL server 4.0.14-standard allowed the use of all lower case names irrespective of the DDL used.

The included MySQL examples were tested with SIMPROCESS in the following environments:

- SIMPROCESS on Linux, MySQL server 3.23.52 on the same Linux host
- SIMPROCESS on Windows, MySQL server 3.23.52 on a Linux host via LAN
- SIMPROCESS on Windows, MySQL server 4.0.14-standard on a Mac OS X host via LAN

SIMPROCESS users are encouraged to send information to the SIMPROCESS Technical Support team about their own experiences with other non-Access SQL databases. Reports of good (or bad) JDBC drivers for various databases are welcomed. Please send compressed example files similar to these to simprocess@caci.com. When sending such reports and/or examples, please be sure and provide as much detail as possible about any special circumstances, platforms involved, etc., and indicate whether it's all right to share any samples with others.

CHAPTER 14

Experiment Manager

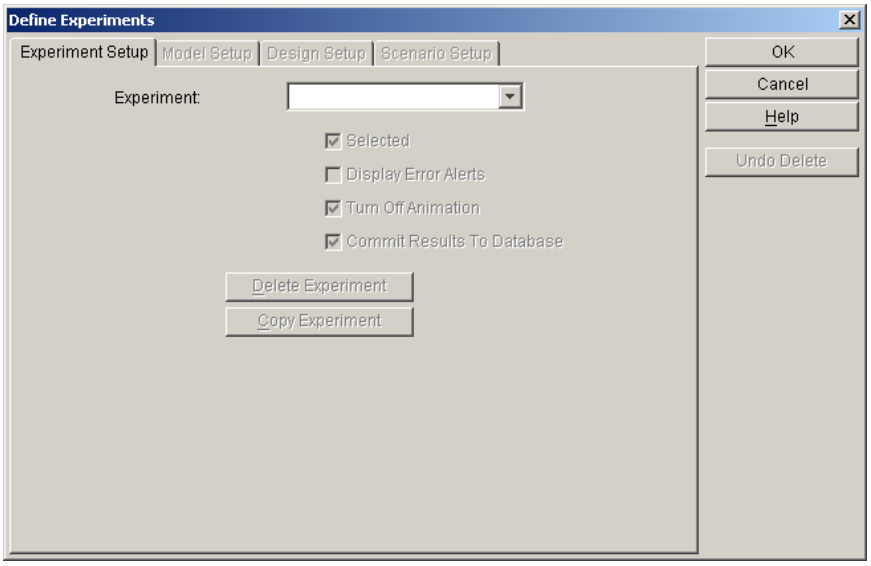
The Experiment Manager sets up model runs that SIMPROCESS will run automatically and, optionally, after each run, place the results in the database. This is accomplished by defining experiments in SIMPROCESS, which are stored in `Experiments.xml` in the `SPUser` directory. SIMPROCESS reads the information from `Experiments.xml`, loads the appropriate model, runs the model, then (optionally) commits the results to the database.

The five items on the **Experiment** menu control the operation of the Experiment Manager.

- Define Experiments
- Run All Experiments
- Run Selected Experiments
- Run Specific Experiment
- Import Database Experiments

Defining Experiments

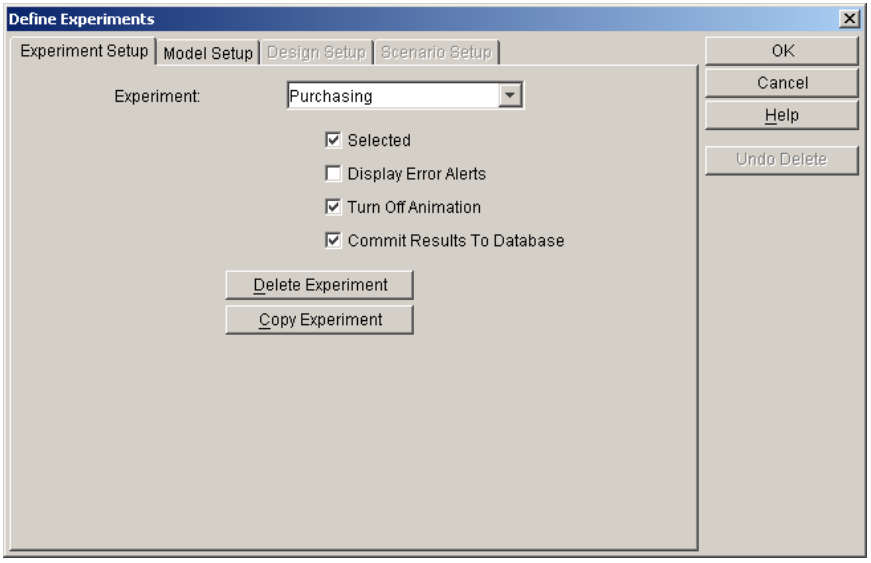
An experiment can have multiple models, a model can have multiple designs, a design can have multiple scenarios, and a scenario can (optionally) have multiple **Model Parameters** (page 215) and **Process Alternatives** (page 73). Selecting **Define Experiments/Using SIMPROCESS...** brings up a dialog experiment information is entered.



If no experiments have been defined, everything is disabled except the **Experiment** combo box. If there are already experiments defined, the first experiment appears in the **Experiment** combo box, and all appropriate items are active. To add to or modify an experiment already defined, select an experiment from the **Experiment** combo box. There may be a slight delay when a predefined experiment is selected. This is because the first model for the experiment must be loaded and then processed.

Entering Experiment Information

There are five fields that require entries for each experiment: **Experiment**, **Selected**, **Display Error Alerts**, **Turn Off Animation**, and **Commit Results To Database**. This shows an example experiment called **Purchasing**. Type the name in the **Experiment** combo box, then press **Enter**. If not already active, entering an experiment name causes the remaining items on the **Experiment Setup** tab and the **Model Setup** tab to activate.

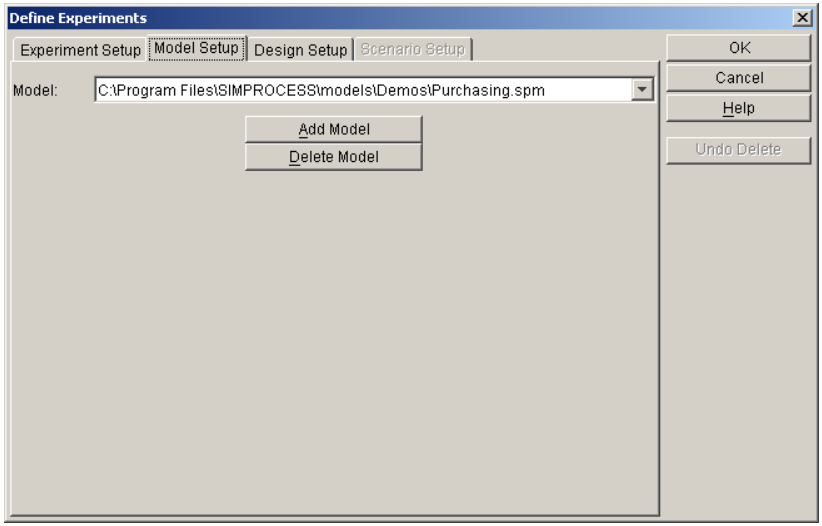


Once the experiment has been named, then check or uncheck **Selected**. The default is checked. **Selected** is used as an option for running experiments. **Display Error Alerts** defaults to unchecked. If unchecked, then SIMPROCESS will run the experiment without stopping to notify of errors. This means SIMPROCESS will run every combination of model, design, and scenario that it can. Those with errors will be skipped over. If **Display Error Alerts** is checked, when SIMPROCESS encounters an error when running the experiment, an error dialog will display that will stop the experiment until the error has been acknowledged by the user. **Turn Off Animation** defaults to checked. If checked, all models in the experiment will run with animation turned off. **Commit Results To Database** defaults to checked as well. When selected, the results from each run will be placed in the SIMPROCESS database. Multiple experiments can be entered. Although not necessary, it is recommended that model, design, and scenario information be entered before adding another experiment.

Entering Model Information

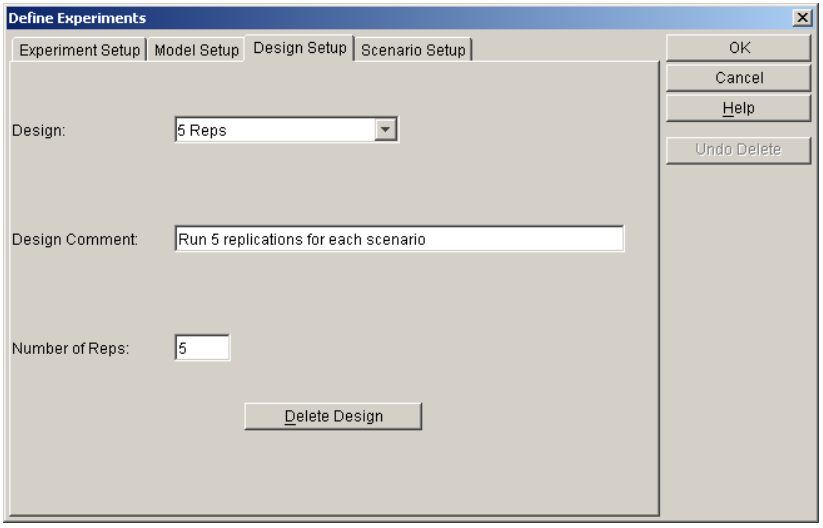
The next tab is **Model Setup**. This tab is active when an experiment name is entered or selected on the **Experiment Setup** tab. To select a model, click the **Add Model** button. This brings up a file chooser dialog. The complete path and the name of the model selected is added to the **Model** combo box. All models added are part of the experiment that was selected on the **Experiment Setup** tab. Although multiple models can be entered before entering design and scenario information, it is recommended that all the design and scenario information (along with parameter and process information, if needed) be entered before entering the next model. If the selected model is moved after being added to an experiment, the model and all associated experiment information (design, scenario, etc.) will be deleted from the experiment the next time **Define Experiments/Using**

SIMPROCESS... is selected.



Entering Design Information

The **Design Setup** tab is active when a model is selected in the **Model** combo box on the **Model Setup** tab. At least one design name is required for each model. The **Design Comment** and **Number of Reps** fields are optional. If no value (integer only) is entered for **Number of Reps**, the last saved model value will be used for each scenario in this design unless there was a previous design for the same model. One design called “5 Reps” is entered for the model `C:\Program Files\SIMPROCESS\models\Demos\Purchasing.spm`.



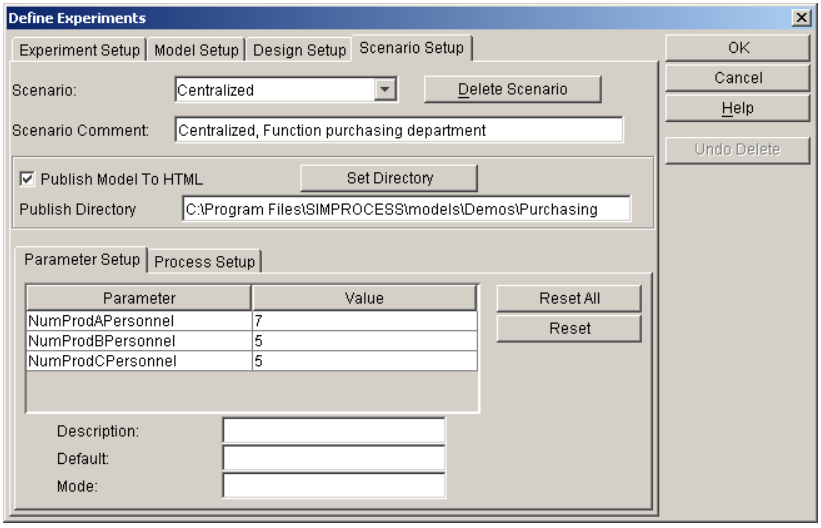
Entering Scenario Information

The **Scenario Setup** tab is active when a design is selected in the **Design** combo box on the **Design Setup** tab. At least one scenario must be entered for each design. If creating a new scenario, a name for the scenario must be entered in the **Scenario** combo box. The **Scenario Comment** field is optional. At this point no more information is required to run a scenario.

Publishing the results of this scenario run to HTML is optional. If **Publish Model To HTML** is selected, a value for **Publish Directory** must be entered. The **Publish Directory** is the destination directory for the HTML output. The name of the directory created for the HTML files is the model name with any spaces replaced by underscores. If a directory with this name already exists within the selected destination directory, either select another destination directory, or rename, move, or delete the existing directory. For instance, in the example below, the directory of the model `Purchasing.spm` was selected as the destination directory. This means the publish process will create a directory named `Purchasing` within the `Purchasing` directory. If a directory named `Purchasing` already existed in `C:\Program File\SIMPROCESS\models\Demos\Purchasing`, an error would occur. So for this example, the HTML files will go in the `C:\Program Files\SIMPROCESS\models\Demos\Purchasing\Purchasing` directory. Thus, if multiple runs of the same model are to be published, a unique destination directory will need to be assigned for each scenario. Usually, if used at all, only one scenario for each model is published to HTML.

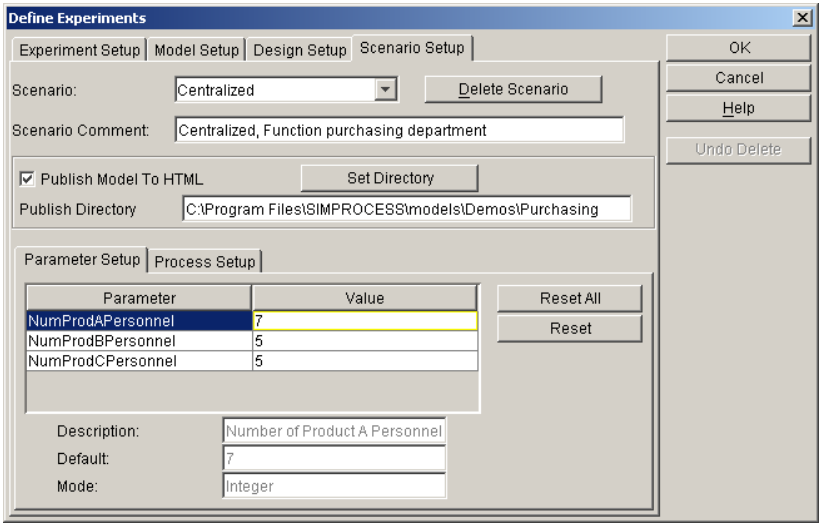
Setting **Model Parameter** values and **Process Alternatives** is optional. If these are not set, then the last saved value for each **Model Parameter** and **Process Alternative** are used. **Model Parameters** are set on the **Parameter Setup** tab, and **Process Alternatives** are set on the **Process Setup** tab. These tabs are part

of the **Scenario Setup** tab.



Entering Model Parameter Information

The **Parameter Setup** tab is used to enter **Model Parameter** values. The attributes for the selected model that have been designated as **Model Parameters** appear in the table. When a **Model Parameter** is selected, its description (comment from the attribute definition), mode (Integer, Real, or String), and default value are displayed in the text fields below the table. Once selected, the value can be changed by typing into the field on the table. Values entered that do not match the mode will not be accepted. The **Reset** button will reset the selected **Model Parameter** to its default value. The **Reset All** button resets all **Model Parameters** to their default values. In this example there are three Model attributes that can be changed for a scenario. (When changing selected scenarios, there may be a slight lag for the **Model Parameter** values to update. This is due to the processing required to update the values.)

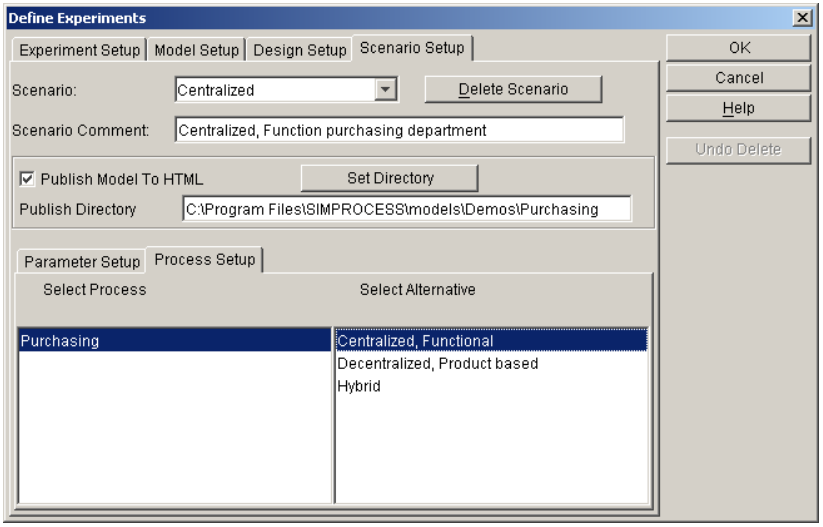


NOTE

If no **Model Parameter** information is entered for a scenario, then the model will run with the last saved values for the **Model Parameters**. If a parameter has been changed for a scenario, and the next scenario uses the same model (that is, a new model is not loaded), then the **Model Parameter** will have the same value as the previous scenario. It will not reset to its default value.

Entering Process Alternative Information

The **Process Setup** tab is used to set the active alternatives for processes that have more than one alternative. The panel on the left displays the processes in the selected model that have more than one alternative. (Since processes are displayed by name, it is recommended that process names not be duplicated within a model.) Once a process is selected, the alternatives for that process will appear in the panel on the right. If an alternative has already been selected, that alternative will be highlighted. If no alternative is highlighted then the model will run with the alternative that was active during the last save of the model. Select the alternative to be active for the current scenario.



In this example the **Centralized, Functional** alternative for the **Purchasing** process will be active for the current scenario.

NOTE

If no process/alternative information is entered for a scenario, then the model will run with the last saved active alternative for each process. If an alternative has been changed for a scenario, and the next scenario uses the same model (that is, a new model is not loaded), then the active alternative for a process will be the same as the previous scenario unless a different alternative is specified in the Experiment Manager.

Undo Delete Button

The **Undo Delete** button is active whenever an experiment, model, design, or scenario has been deleted. The button remains active until used or until the scope of the deleted item has been lost. An experiment can be restored any time before another delete occurs. A model can be restored as long as the experiment to which it belongs remains the selected experiment. A design can be restored as long as the experiment and model to which it belongs remain selected. Finally, a scenario can be restored as long as the experiment, model, and design to which it belongs remain selected.

Running Experiments

Once the experiments have been defined, run the experiments. This section discusses starting experiments, the operation of experiments, how to interact with experiments, and how to generate standard reports from experiments.

Starting Experiments

There are three options for running experiments.

- Run All Experiments
- Run Selected Experiments
- Run Specific Experiment

Run All Experiments

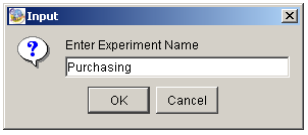
The menu item **Run All Experiments** causes SIMPROCESS to attempt to run every experiment defined. This option ignores the **Selected** field.

Run Selected Experiments

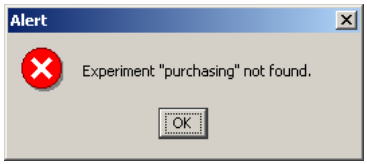
When this menu item is selected, SIMPROCESS attempts to run the experiments in which the **Selected** field is checked.

Run Specific Experiment

This menu item specifies one experiment to run. When selected, enter the experiment name in the dialog.



If no match occurs, an error message appears stating the experiment could not be found in the database. Case does matter when selecting a specific experiment. The case and spelling must match.


Alert
Experiment "purchasing" not found.
OK

Experiment Operation

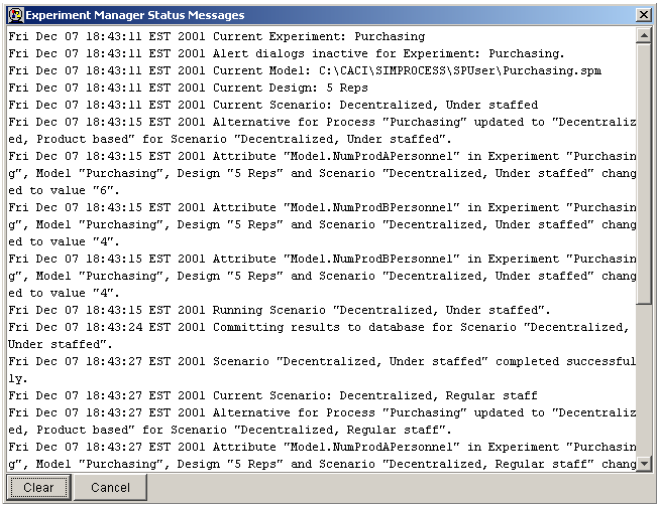
The Experiment Manager operates as follows when running experiments:

Once an experiment begins, SIMPROCESS begins a sequence of steps. Each step occurs if the previous completes successfully. The steps to running experiments are:

1. Load Experiments.xml.
2. Prompt to save current work if necessary.
3. Enter a loop with sub loops.
    Find Experiment.
        Find Model.
            Find Design.
                Find Scenario.
                Find Parameters.
                Find Process Alternatives.
                Load Model.
                Verify Design.
                Run Model.
                Commit results to database.
                End loop.
            End loop.
        End loop.
    End loop.
4. Display status message on success of experiments.

Experiment Trace

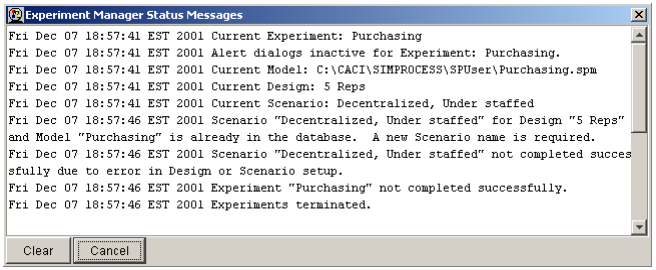
During experiment execution, the Experiment Manager displays a trace showing the steps that have been completed and the current step. The trace includes the date, time, and a message.

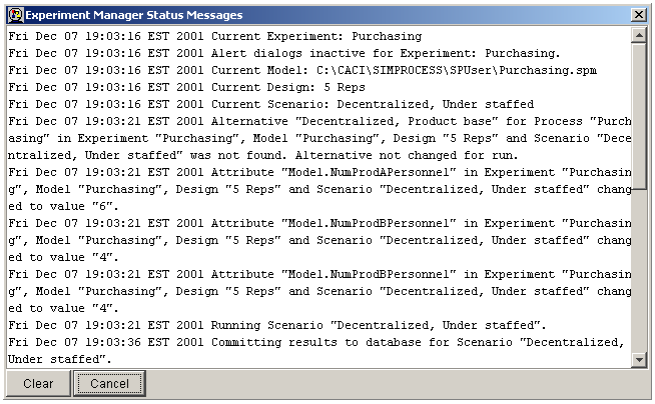

Experiment Manager Status Messages
Fri Dec 07 18:43:11 EST 2001 Current Experiment: Purchasing
Fri Dec 07 18:43:11 EST 2001 Alert dialogs inactive for Experiment: Purchasing.
Fri Dec 07 18:43:11 EST 2001 Current Model: C:\CACI\SIMPROCESS\SPUser\Purchasing.spm
Fri Dec 07 18:43:11 EST 2001 Current Design: 5 Reps
Fri Dec 07 18:43:11 EST 2001 Current Scenario: Decentralized, Under staffed
Fri Dec 07 18:43:15 EST 2001 Alternative for Process "Purchasing" updated to "Decentraliz
ed, Product based" for Scenario "Decentralized, Under staffed".
Fri Dec 07 18:43:15 EST 2001 Attribute "Model.NumProdAPersonnel" in Experiment "Purchasin
g", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" chang
ed to value "6".
Fri Dec 07 18:43:15 EST 2001 Attribute "Model.NumProdBPersonnel" in Experiment "Purchasin
g", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" chang
ed to value "4".
Fri Dec 07 18:43:15 EST 2001 Attribute "Model.NumProdBPersonnel" in Experiment "Purchasin
g", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" chang
ed to value "4".
Fri Dec 07 18:43:15 EST 2001 Running Scenario "Decentralized, Under staffed".
Fri Dec 07 18:43:24 EST 2001 Committing results to database for Scenario "Decentralized,
Under staffed".
Fri Dec 07 18:43:27 EST 2001 Scenario "Decentralized, Under staffed" completed successful
ly.
Fri Dec 07 18:43:27 EST 2001 Current Scenario: Decentralized, Regular staff
Fri Dec 07 18:43:27 EST 2001 Alternative for Process "Purchasing" updated to "Decentraliz
ed, Product based" for Scenario "Decentralized, Regular staff".
Fri Dec 07 18:43:27 EST 2001 Attribute "Model.NumProdAPersonnel" in Experiment "Purchasin
g", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Regular staff" chang
Clear
Cancel

It is important to examine the Experiment Manager trace, since it will give the complete status of the experiments. The above example shows the experiment, alert dialog status (see below), model, design, and scenario. Also, it shows the **Process Alternatives** that were active and the values of the **Model Parameters** for the scenario.

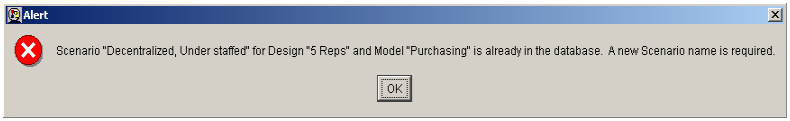
Experiment Errors

As explained in the instructions for defining experiments, when the **Display Error Alerts** field is not selected, interactive error messages are suppressed. However, error messages will appear in the Experiment Manager trace. The Experiment Manager trace shows which experiments completed successfully and which encountered errors. Especially important are the messages that show errors with the **Process Alternatives** and **Model Parameters**.

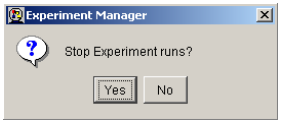

Experiment Manager Status Messages
Fri Dec 07 18:57:41 EST 2001 Current Experiment: Purchasing
Fri Dec 07 18:57:41 EST 2001 Alert dialogs inactive for Experiment: Purchasing.
Fri Dec 07 18:57:41 EST 2001 Current Model: C:\CACI\SIMPROCESS\SPUser\Purchasing.spm
Fri Dec 07 18:57:41 EST 2001 Current Design: 5 Reps
Fri Dec 07 18:57:41 EST 2001 Current Scenario: Decentralized, Under staffed
Fri Dec 07 18:57:46 EST 2001 Scenario "Decentralized, Under staffed" for Design "5 Reps"
and Model "Purchasing" is already in the database. A new Scenario name is required.
Fri Dec 07 18:57:46 EST 2001 Scenario "Decentralized, Under staffed" not completed succes
sfully due to error in Design or Scenario setup.
Fri Dec 07 18:57:46 EST 2001 Experiment "Purchasing" not completed successfully.
Fri Dec 07 18:57:46 EST 2001 Experiments terminated.
Clear
Cancel


Experiment Manager Status Messages
Fri Dec 07 19:03:16 EST 2001 Current Experiment: Purchasing
Fri Dec 07 19:03:16 EST 2001 Alert dialogs inactive for Experiment: Purchasing.
Fri Dec 07 19:03:16 EST 2001 Current Model: C:\CACI\SIMPROCESS\SPUser\Purchasing.spm
Fri Dec 07 19:03:16 EST 2001 Current Design: 5 Reps
Fri Dec 07 19:03:16 EST 2001 Current Scenario: Decentralized, Under staffed
Fri Dec 07 19:03:21 EST 2001 Alternative "Decentralized, Product base" for Process "Purchasing" in Experiment "Purchasing", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" was not found. Alternative not changed for run.
Fri Dec 07 19:03:21 EST 2001 Attribute "Model.NumProdAPersonnel" in Experiment "Purchasing", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" changed to value "6".
Fri Dec 07 19:03:21 EST 2001 Attribute "Model.NumProdBPersonnel" in Experiment "Purchasing", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" changed to value "4".
Fri Dec 07 19:03:21 EST 2001 Attribute "Model.NumProdBPersonnel" in Experiment "Purchasing", Model "Purchasing", Design "5 Reps" and Scenario "Decentralized, Under staffed" changed to value "4".
Fri Dec 07 19:03:21 EST 2001 Running Scenario "Decentralized, Under staffed".
Fri Dec 07 19:03:36 EST 2001 Committing results to database for Scenario "Decentralized, Under staffed".
Clear
Cancel

When the **Display Error Alerts** field is selected, error dialogs will appear that pause the Experiment until the error is acknowledged.


Alert
Scenario "Decentralized, Under staffed" for Design "5 Reps" and Model "Purchasing" is already in the database. A new Scenario name is required.
OK

Also, after the error displays, if there are more experiments to be run, a dialog appears with the option to stop all experiment runs.



If experiments are to be run overnight, it is recommended that the **Display Error Alerts** field not be selected for every experiment that is to be run. That way SIMPROCESS will run every combination of Experiment, Model, Design, and Scenario that it can. Otherwise, if an error occurs, processing stops until the error is acknowledged.

Interacting With Experiments

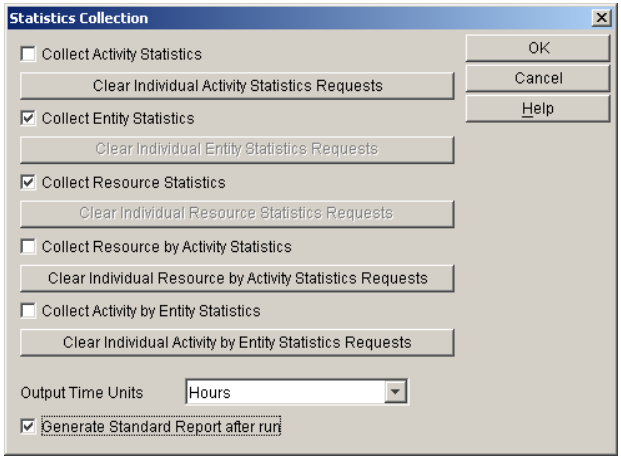
A model run by the Experiment Manager can be interacted with in the same manner as a model that was user initiated. This means the animation can be turned on or off, the animation settings can be

changed, the model can be navigated, etc.

Experiments can be stopped early by stopping a model run. An experiment cannot be stopped while loading experiment information, loading a model, or committing results to the database. If the **Display Error Alerts** field is selected, there will be an option to stop completely. Otherwise every run must be stopped to stop all experiment, model, design, and scenario combinations.

Generating Standard Reports From Experiments

If selected, the Experiment Manager automatically commits the run results to the database. If an ASCII version of the Standard Report is needed, go to **Define Global Statistics Collection** on the **Report** menu. Select **Generate Standard Report after run**. This will create a file in the model's directory that will contain the report for every replication, the sum of the replications, and the average of the replications.



Importing Database Experiments

Experiments that were defined in earlier versions of the SIMPROCESS database can be imported into `Experiments.xml`. Experiments that are imported from the database are not removed from the database. There are three options for importing:

- All
- Selected
- Specific...

All imports all experiments that are in the database. **Selected** imports those experiments in the database that have **Selected** checked. **Specific...** brings up a dialog in which an experiment name is specified.

During import, the message “Importing Experiments” appears in the status bar. When complete, the message “Experiment Import Complete” appears. If errors occurred during the import procedure, the message “Experiment Import Failed” appears. Errors that cause the import procedure to fail include not being able to contact the database or some type of SQL error.

CHAPTER 15

OptQuest for SIMPROCESS

In today's highly competitive global environment, people are faced with many difficult decisions, such as allocating financial resources, building facilities, managing inventories, determining product mix strategies, and more. Modeling a decision problem in SIMPROCESS discovers what performance measures can be expected using a certain strategy.

A strategy can be defined as a certain set of values for the model parameters. Other words for strategy include scenario and solution. Note that "solution" refers to the model parameter values (inputs to the simulation), *not* the resulting values of the performance measures.

Suppose the goal was to find the best strategy (without using OptQuest). Model parameter values for a strategy being considered would have to be entered into SIMPROCESS and the results analyzed. Then, this process would have to be repeated for every strategy under consideration. (Experiment Manager automates running models with various values for model parameters. See "Experiment Manager" on page 334.) Often, it would not be clear how to adjust the model parameters from one simulation to the next. This type of search is tedious and, in problems with thousands or millions of potential alternatives, impractical.

OptQuest enhances SIMPROCESS by automating the search for an optimal strategy.

Note that OptQuest for SIMPROCESS is licensed separately from SIMPROCESS.

Overview of OptQuest for SIMPROCESS

Since OptQuest is an optimization tool, it is attempting to minimize or maximize the value of a performance measure based on limits (constraints, upper bounds, and lower bounds). OptQuest automatically runs SIMPROCESS models varying the values for the model parameters searching for optimum results within the specified limits.

When the optimization runs:

OptQuest feeds a potential solution into SIMPROCESS model by setting the decision variable (model parameter) values.

SIMPROCESS runs one simulation (which may include multiple replications) to evaluate the solution.

OptQuest takes the resulting response values from SIMPROCESS.

OptQuest analyzes the results of the simulation and uses its intelligent search procedures to generate a new potential solution, which it then sends to SIMPROCESS.

OptQuest repeats this process. Its ultimate goal is to find the solution that optimizes (maximizes or minimizes) the value of the model's objective.

Elements of an OptQuest Optimization

Optimizations consist of an objective (minimize or maximize), decision variables, and constraints (constraints are optional).

Objective: An expression that represents the model's objective, such as minimizing queues or maximizing profits.

Decision Variables: Variables that can be meaningfully manipulated to affect the performance of a simulated system. The model parameters in SIMPROCESS are called decision variables in OptQuest.

Constraints: Relationships among decision variables and output variables. For example, a constraint might ensure that the total amount of money allocated among various investments cannot exceed a specified amount, or the processing time of a system cannot be greater than a certain value.

There can be bounds (upper and lower) on the decision variables and performance measure constraints (statistics).

Using OptQuest: An Overview

Follow these steps to use OptQuest.

Create a simulation model, or open a simulation model.

Prepare the model for optimization. This includes creating and assigning model parameters, establishing a performance measure to optimize, making sure the model is complete, verifying and validating the model, and making sure the model runs with no errors.

Set up the optimization, or select previous optimization settings (**Tools/OptQuest** menu). The following steps apply to creating a new optimization. Previously defined optimization settings can be modified or deleted.

a. Define the objective.

b. Select the decision variables.

c. Define constraints.

d. Set process alternatives.

e. Select optimization options.

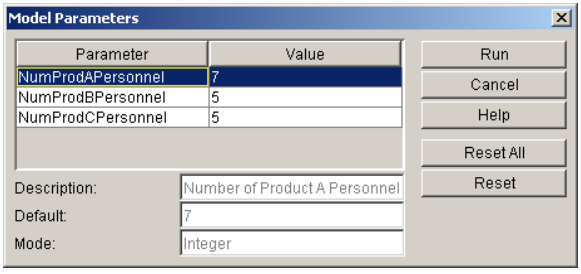
Run the optimization. When **Start** is selected, the model is saved, and the OptQuest interface appears. From this interface the user can monitor the optimization, stop the optimization, and create reports once complete. Also, if selected, OptQuest will prompt for more iterations when approaching the maximum iteration.

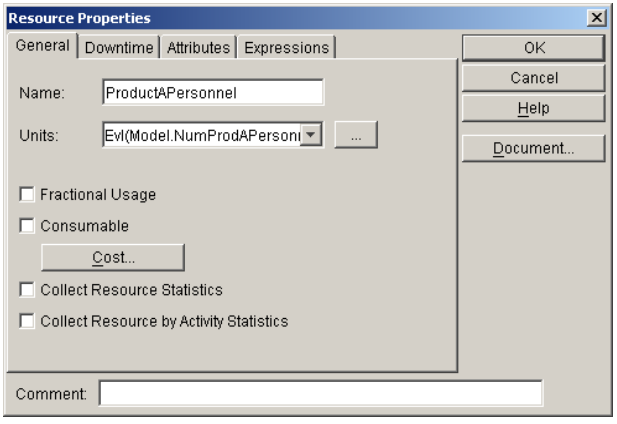
Interpret the results.

Optimization Setup

Preparing for Optimization

In order to use OptQuest with a model, the model must have model parameters of type Integer and/or Real. Model parameters are user controlled values that typically set some of the initial conditions of a simulation. For instance, if Truck is a resource in the model, a model parameter could be used to set the number of the resource Truck available. In the Inventory demonstration model (see *SIMPROCESS Getting Started Manual*) reorder levels are controlled by model parameters. When a model is run that has model parameters, a dialog appears that allows values of the model parameters to be changed before the run begins. The image below shows the model parameter dialog from the Purchasing demonstration model. There are three model parameters: `NumProdAPersonnel`, `NumProdBPersonnel`, and `NumProdCPersonnel`. All three of these are Model Attributes and their **Mode** is Integer. These model parameters set the number of units of the resources ProductAPersonnel, ProductBPersonnel, and ProductCPersonnel.





Since OptQuest uses the Integer and Real model parameters as decision variables, when OptQuest runs the model as part of the optimization, it sets the values of the model parameters for each run.

Another requirement for optimization is an objective. Therefore there must be a performance measure in the model to maximize or minimize. This performance measure could be one of the standard statistics collected by SIMPROCESS or a specialized statistic, which could consist of a linear or non-linear combination of various standard statistics. Again, referring to the Purchasing demonstration model, the objective is to minimize the capacity cost of all the resources. Since capacity cost is collected automatically, this statistic does not have to be created. However, in the Inventory demonstration model, the objective is to minimize inventory and minimize the cycle time of an order. Since only one value can be optimized, these performance measures must be combined into one. In the Inventory demonstration model there is a linear combination of the two performance measures. This combination is in the **End Simulation** expression of the **Model Expressions** (**Define/Model Expressions**).

```
Model.OrderTime := GetEntityStatistic("Order", "tokendelay", "Avg",
Replication);
Model.FinishedProduct := GetResourceStatistic("FinProduct",
"resrcidle", "Avg", Replication);

Model.InventoryPlusOrderTime := Model.FinishedProduct + (5.0 *
Model.OrderTime);
```

When combining performance measures the Expression language will be needed to retrieve statistics collected during the simulation. (See “Accessing Statistics During Simulation” on page 267.) The example above shows values being assigned to three Model Attributes: `OrderTime`, `FinishedProduct`, and `InventoryPlusOrderTime`. `OrderTime` is assigned the average cycle time for the entity **Order**. `FinishedProduct` is assigned the average number of units idle of the resource **FinProduct**. `InventoryPlusOrderTime` is a linear combination of the two, and statistics are collected for that attribute. Thus, the Model Attribute `InventoryPlusOrderTime` is the value to minimize. Note that the System Attribute `Replication` is used to get the value from the appropriate replication of the simulation.

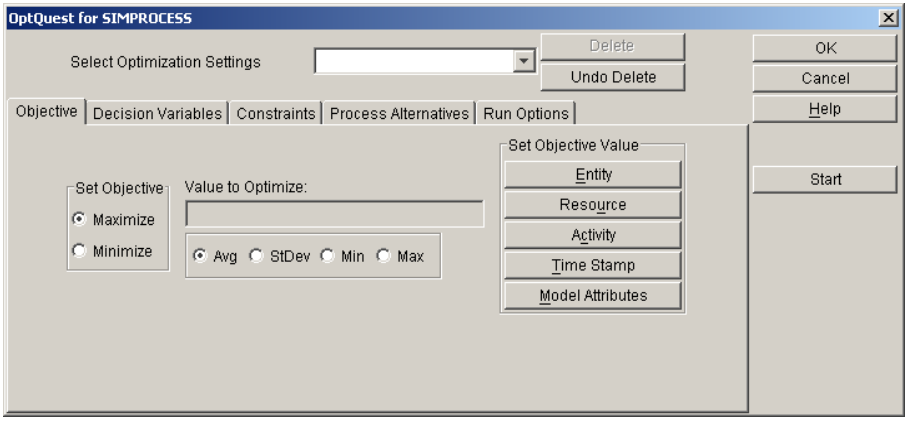
Standard or specialized statistics can also be used as constraints in OptQuest. Therefore, if performance measures need to be used as constraints, make sure the appropriate statistics are being collected. For example, the values being assigned to `OrderTime` and `FinishedProduct` are also constraints in the Inventory demonstration model.

The final steps in preparing a model for optimization apply whether or not OptQuest is intended to be used. Make sure the model is complete. That is, all required fields in properties dialogs have been defined (especially if portions of the model have come from other models), and all activities and processes are connected. Run the model for several replications to ensure there are no errors. Determine the appropriate number of replications needed to achieve statistical significance. Finally, and most importantly, make sure the model accurately reflects the system being modeled.

Defining An Optimization

Optimizations can only be defined for the currently active model in SIMPROCESS. Thus, if the model to optimize is not loaded, load it; or if already loaded, make sure the model to optimize is the active model.

Select **Tools/OptQuest**. (If **OptQuest** is not enabled, contact the SIMPROCESS Sales Manager to purchase a license for OptQuest for SIMPROCESS.) This brings up the OptQuest for SIMPROCESS setup dialog.



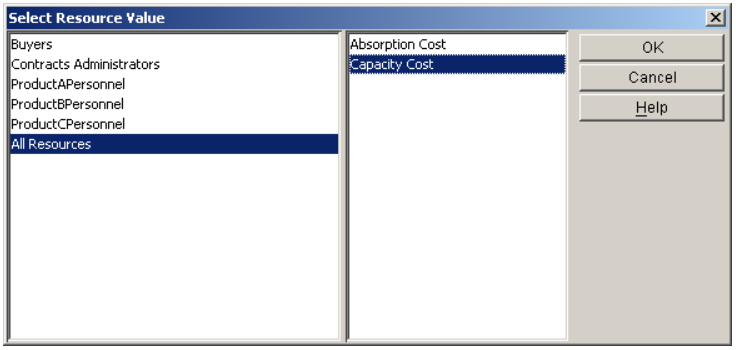
If no optimizations have been created for the model, **Select Optimization Settings** will be empty. The first step in defining an optimization is to give it a name. Enter a name in **Select Optimization Settings**. If there are already other optimization settings defined, entering a new name creates a new setting. To switch between settings, simply select the desired setting from **Select Optimization Settings**.

Once a name has been entered, continue defining the optimization. There are five tabs on the dialog: **Objective**, **Decision Variables**, **Constraints**, **Process Alternatives**, and **Run Options**. The tabs can be edited in any order.

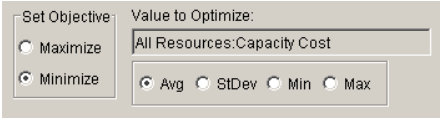
Objective

The **Objective** tab sets whether to **Minimize** or **Maximize** and the value to optimize. The buttons on the right are used to select the value to optimize. **Entity**, **Resource**, **Activity**, **Time Stamp**, or **Model Attribute** values can be optimized. For the Purchasing demonstration model, the objective is to minimize the capacity cost of all the resources. So **Minimize** was selected, then the **Resource** button was selected to

choose the appropriate value to minimize.



On the left are all the resources defined in the model, plus an additional item named **All Resources**. When an item is selected on the left, the possible values are displayed on the right. In this example, **All Resources** is selected on the left and **Capacity Cost** on the right. When **OK** is selected, **All Resources:Capacity Cost** appears in **Value to Optimize**.



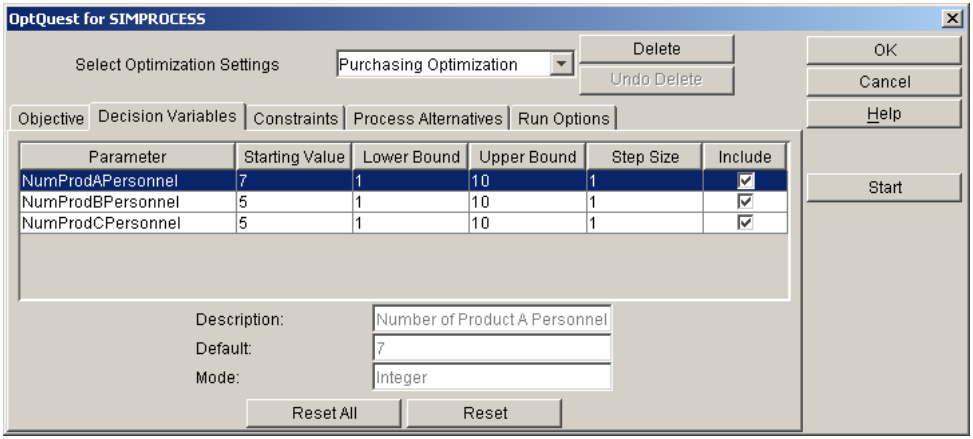
In the Inventory model, the **Value to Optimize** is **Model.InventoryPlusOrderTime:Value**. There are four options for the **Value to Optimize**: **Avg** (Average), **StDev** (Standard Deviation), **Min** (Minimum), and **Max** (Maximum). For this example, the average capacity cost for all the resources is needed. Since stochastic (random) simulation models should be run for more than one replication, the capacity cost of all resources for each replication is averaged.

Note about Min and Max: Min or Max should only be used when the constraints should bring convergence. For instance, if minimizing the maximum wait time was the goal, **Max** should be chosen for the **Value to Optimize**. Doing that, though, assumes there are constraints that would limit the maximum.

Decision Variables

The Decision Variables tab contains a table similar to the table on the Model Parameters dialog. This table lists all the model parameters in the model (no matter what **Mode**). However, only those model parameters whose **Mode** is Integer or Real are decision variables. The **Starting Value** is the value OptQuest will use on the first iteration. If new values are not entered, the **Starting Value** is the default value of the model parameter assigned at the time the attribute was defined. The last column of the

table, **Include**, determines which decision variables OptQuest will modify during the optimization. The remaining columns, **Lower Bound**, **Upper Bound**, and **Step Size** apply only to model parameters whose **Mode** is Integer or Real. If the model parameter is not one of those modes, N/A will be entered in appropriate cell. Also, if the **Mode** is Real, N/A will be entered in the **Step Size** column of that row. If **Lower Bound** is left blank, negative infinity is assumed. Likewise, if **Upper Bound** is left blank, infinity is assumed. The **Reset** and **Reset All** buttons work as on the Model Parameters dialog. These buttons only apply to the **Starting Value** column.



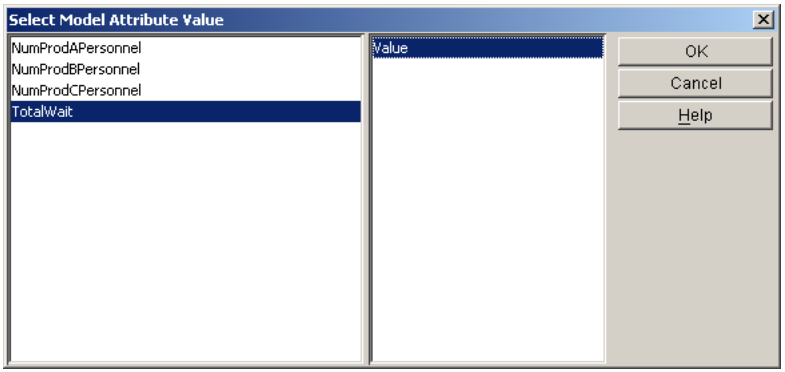
Constraints

The **Constraints** tab is where constraints are defined. (Constraints are not required for an optimization, but are usually used in an optimization.) Two types of constraints can be defined. The first type is a constraint on a performance measure of the model. The **Entity**, **Resource**, **Activity**, **Time Stamp**, and **Model Attributes** buttons work as on the **Objective** tab. These buttons allow performance measures to be selected for constraint. Unlike the **Objective**, though, which can only be one performance measure, more than one performance measure constraints can be added to the optimization. Also, on performance measure constraints, there is an **Upper Bound** and/or a **Lower Bound**. (Note: If there are no bounds for a performance measure, do not include it as a constraint.) In the Purchasing model there is a Model Attribute named `TotalWait`. This attribute represents the total amount of time all entity types (Product A, Product B, and Product C) wait for resources. The code below is from the **End Simulation** expression of the **Model Expressions** (**Define/Model Expressions**).

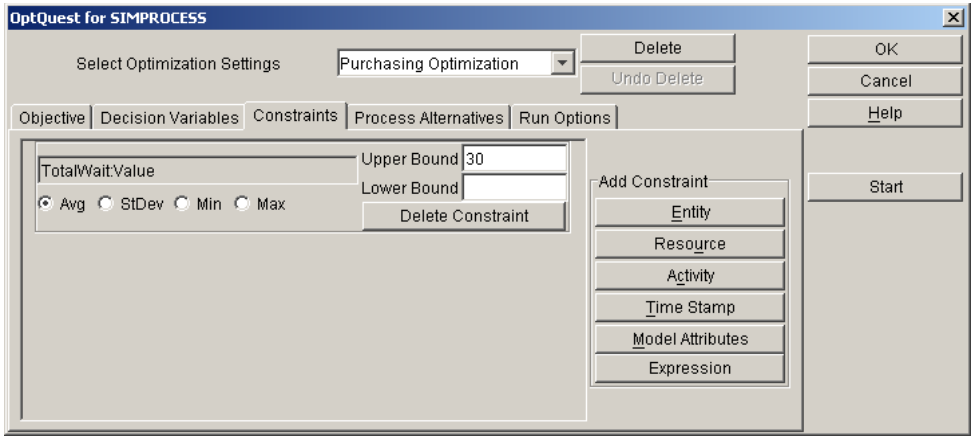
```
aWait, bWait, cWait : REAL;
aWait := GetEntityStatistic("Product A", "tokenwaitdelay", "Avg",
Replication);
bWait := GetEntityStatistic("Product B", "tokenwaitdelay", "Avg",
Replication);
```

```
cWait := GetEntityStatistic("Product C", "tokenwaitdelay", "Avg",
Replication);
Model.TotalWait := aWait + bWait + cWait;
```

The local variables `aWait`, `bWait`, and `cWait` contain the average wait time for Product A, Product B, and Product C respectively. The Model Attribute `TotalWait` contains the sum of all the waits. Selecting the **Model Attributes** button brings up the list of the Model Attributes in the Purchasing model. `TotalWait` was selected, then `Value` was selected.



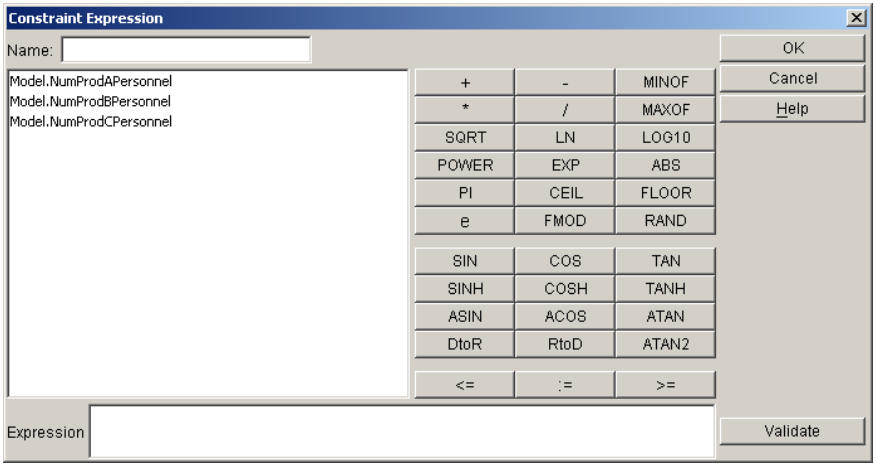
Performance measure constraints appear as the objective except an **Upper Bound** field, a **Lower Bound** field, and a **Delete Constraint** button are added.



As with the decision variables, a blank **Lower Bound** assumes negative infinity, and a blank **Upper Bound** assumes infinity. Once a performance measure constraint has been added, only the **Upper Bound**, **Lower**

Bound, and type of statistic can be edited. If the type of value chosen needs to be changed, the constraint must be deleted and recreated.

The second type of constraint is an expression constraint. An expression constraint defines mathematical relationships between decision variables. The **Expression** button is used to create expression constraints. This button displays a dialog that lists the decision variables on the left and the allowed mathematical operators and functions on the right. The example below shows the Purchasing model. Note that the decision variable names must be the fully qualified SIMPROCESS attribute name. That is, the type of the attribute (Model, Entity, etc.) must be included.



A name must be entered for the constraint in the **Name** field. Names for expression constraints within the same optimization setting must be unique. The expression can be typed directly into the **Expression** text area, or by clicking on the decision variable or mathematical operator or function. The syntax is the same as used in the SIMPROCESS Expression language. Some mathematical functions allowed by OptQuest are not allowed in the SIMPROCESS Expression language, therefore all of the functions allowed by OptQuest are listed in the following table along with descriptions.

Expression Constraint Functions

Function	Description
ABS(x)	Returns the absolute value of x.

Expression Constraint Functions

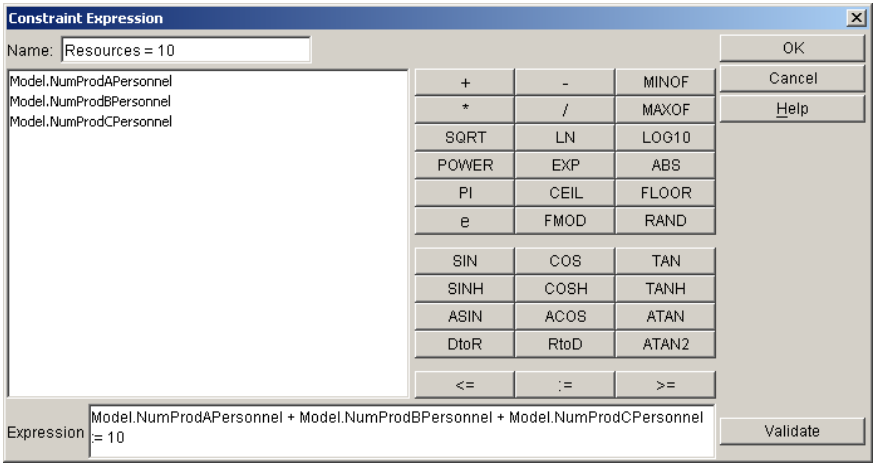
Function	Description
ACOS(x)	Returns the arccosine of x in the range 0 to n radians. x is between -1 and 1.
ASIN(x)	Returns the arcsine of x in the range –n/2 to n/2 radians. x is between -1 and 1.
ATAN(x)	Returns the arctangent of x in the range of –p/2 to p/2 radians. If x is 0, atan returns 0.
ATAN2(x, y)	Returns the arctangent of y/x in the range –pi to pi radians. If both parameters of ATAN2 are 0, the function returns 0.
CEIL(x)	Returns the smallest whole number greater than or equal to x.
COS(x)	Returns the cosine of x, where x is an angle in radians.
COSH(x)	Returns the hyperbolic cosine of x, where x is an angle in radians.
DtoR(x)	Converts degrees to radians.
e	Mathematical constant e, approximately equal to 2.718.
EXP(x)	Returns *e* raised to the x power.
FLOOR(x)	Returns the largest whole number less than or equal to x.
FMOD(x, y)	Returns the remainder of x / y.
LN(x)	Returns the base *e* logarithm of x.

Expression Constraint Functions

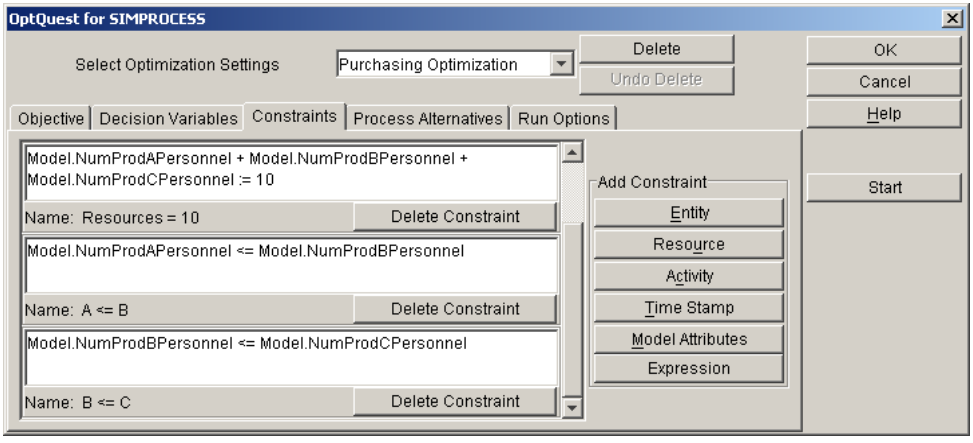
Function	Description
LOG10(x)	Returns the base 10 logarithm of x.
MAXOF(x, y)	Returns the larger of two numbers. (Note: Unlike the SIMPROCESS MAXOF, only two parameters are allowed.)
MINOF(x, y)	Returns the smaller of two numbers. (Note: Unlike the SIMPROCESS MINOF, only two parameters are allowed.)
PI	Mathematical constant pi, approximately equal to 3.14159.
POWER(x, y)	Returns x raised to the y power.
RAND	Returns a random number between 0 and 1 inclusive.
RtoD(x)	Converts radians to degrees.
SIN(x)	Returns the sine of x, where x is an angle in radians.
SINH(x)	Returns the hyperbolic sine of x, where x is an angle in radians.
SQRT(x)	Returns the square root of x.
TAN(x)	Returns the tangent of x, where x is an angle in radians.
TANH(x)	Returns the hyperbolic tangent of x, an angle in radians.

The optimization setup for the Purchasing model is highly constrained. This is because of the three

expression constraints. The first constraint is named **Resources = 10**. This constraint requires that the sum of the decision variables (model parameters) must equal 10. Since these decision variables set the number of units of each resource type, the name **Resources = 10** was assigned. The dialog has a **Validate** button. This button allows validation of the syntax of the expression constraint before selecting **OK**.



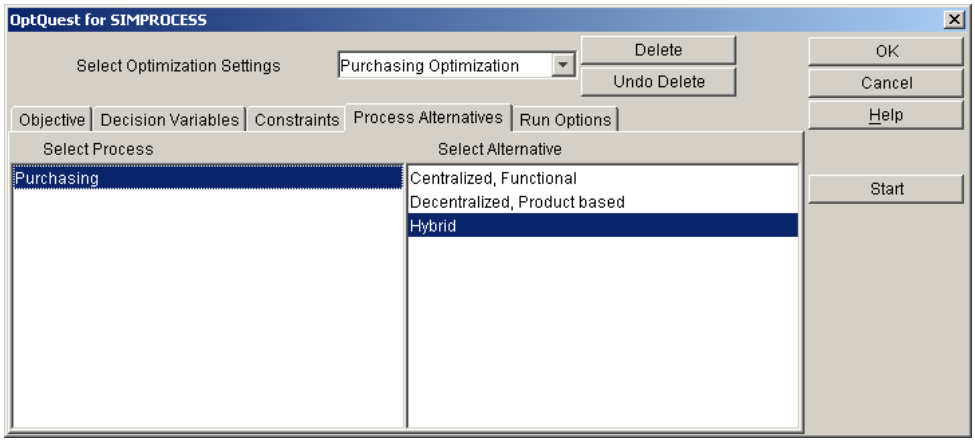
There are two other expression constraints in the Purchasing model, **A <= B** and **B <= C**. These constraints state that the number of units of the resource ProductAPersonnel must be less than or equal to the number of units of the resource ProductBPersonnel, and the number of units of the resource ProductBPersonnel must be less than or equal to the number of units of ProductCPersonnel. Scrolling down on the **Constraints** tab brings all three expression constraints into view.



Expression constraints can be modified from the Constraints tab by clicking in the text area and changing as necessary. However, expression constraint validation is not available. To use validation, the constraint must be deleted and recreated.

Process Alternatives

The **Process Alternatives** tab displays all processes in the model that have more than one alternative. When a process is selected on the left, the alternatives for that process are displayed on the right. This allows the alternative to be selected that will be active for the optimization. If no alternative is selected for a process, the alternative that was active the last time the model was saved will be active for the optimization. In the Purchasing model, the Purchasing process is the only process that has more than one alternative, thus, it is the only process listed on the left. The Purchasing process' three alternatives are listed on the right.

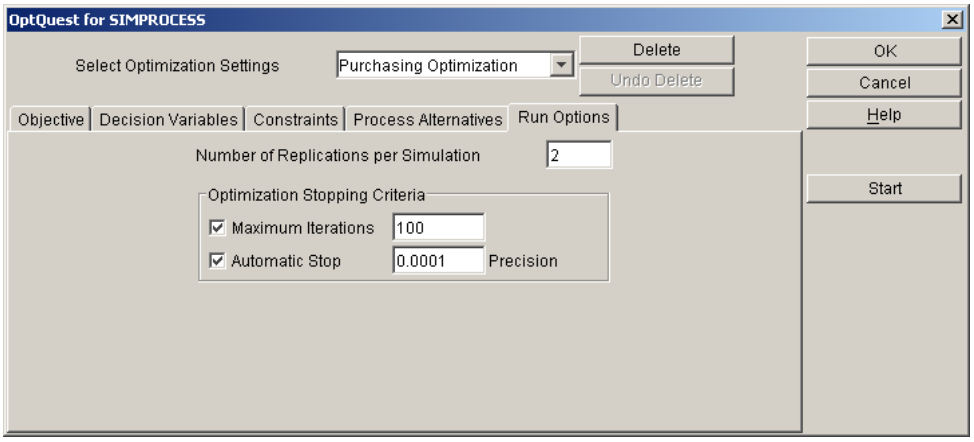


Run Options

The Run Options tab sets the number of replications for each simulation and the optimization stopping criteria. Unless the model is discrete, it is recommended that each simulation be run for more than one replication. The number of replications needed should be determined before setting up the optimization. If no value is entered, each simulation run will run with the number of replications last saved in the model. If a value is entered, that value will be reflected in the **Number of Replications** in the **Run Settings** of the model the next time the model is opened after the optimization. In the Purchasing model, the **Number of Replications per Simulation** is set to 2. This was set to a small number for demonstration purposes only. Only two replications and the tight constraints cause the Purchasing optimization to run quickly.

Apart from user intervention, the length of the optimization is controlled by two options: **Maximum Iterations** and **Automatic Stop**. At least one of the stopping criteria must be selected. Both options can

be selected. If both are selected, the criteria that is satisfied first will stop the optimization. **Maximum Iterations** is the maximum number of iterations OptQuest will attempt before stopping the optimization. The value must be an integer greater than zero. When **Automatic Stop** is selected, the optimization stops when the value of the objective stops improving. **Precision** determines when two objective values are considered equal. The default is 0.0001.

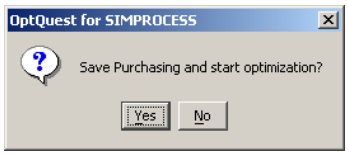


Saving Optimization Settings

Selecting **OK** will close the dialog and add the defined optimization settings to the model. The model must be saved for the optimization settings to persist. Selecting **Start** will close the dialog, add the defined optimization settings to the model, and save the model. Thus, performing another save is not necessary. **Cancel** closes the dialog and discards any changes.

Running an Optimization

To run an optimization, if the optimization settings dialog is not already displayed, select **OptQuest** from the **Tools** menu. Once the optimization settings dialog has appeared, either define an optimization or select a previously defined optimization. Select the **Start** button. At that point a dialog will appear asking for confimation before saving the model and starting the optimization. If **No** is selected, the operation is canceled. If **Yes** is selected, the dialog closes, the model is saved, and the optimization starts.

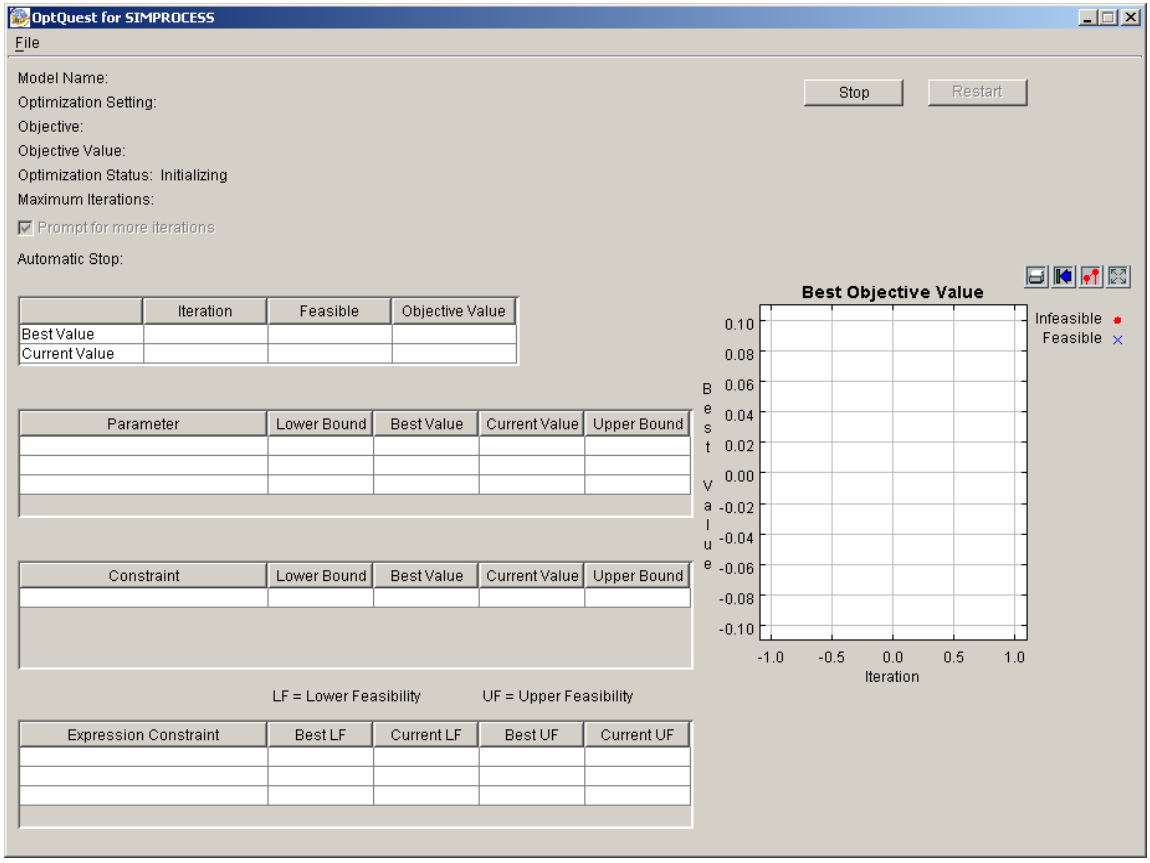


OptQuest for SIMPROCESS Interface

An OptQuest for SIMPROCESS optimization runs in a separate Java Virtual Machine (JVM) and uses a separate interface from SIMPROCESS. Therefore, once an optimization has started, SIMPROCESS can continue to be used without affecting the optimization. This means multiple optimizations can run simultaneously. However, that may not be practical, since running an optimization is very CPU intensive (since it is running a simulation, which monopolizes the CPU), and, depending on the size of the model, memory intensive. Also, it may not be practical to run a simulation with SIMPROCESS while an optimization is running for the same reasons. Running multiple optimizations and/or simulations will often perform better on non-Windows systems.

The OptQuest for SIMPROCESS interface primarily consists of text, tables, and a graph to monitor the optimization. There is a button to stop the optimization, and there are reporting options on the **File** menu once the optimization is complete.

When the interface appears, all status objects are empty except for the **Optimization Status** field, which displays **Initializing**. The tables show the status of the objective value, the decision variables, the performance measure constraints, and the expression constraints. The objective value table and the decision variables table will always appear. The performance measure constraints table and the expression constraints table will only appear if those types of constraints exist. The graph plots the best objective value based on whether or not the best is feasible. The example below is from the Purchasing model.



Status Text

The following status text is displayed:

- **Model Name** - name of the model being optimized
- **Optimization Setting** - the name of the optimization setting selected when the optimization was started
- **Objective** - Minimize or Maximize
- **Objective Value** - the performance measure selected for optimization
- **Optimization Status** - Initializing, Running Iteration n, Complete, Stopping Optimization, User Terminated, or Error
- **Maximum Iterations** - number of iterations or Off
- **Automatic Stop** - On or Off

Optimization Status descriptions:

- **Initializing** - Optimization is in setup stage
- **Running Iteration n** - Optimization is running the *n*th iteration
- **Optimal Solution Found** - Optimization completed normally with no errors
- **Stopping Optimization** - Optimization is in the process of stopping because user selected **Stop** button
- **User Terminated** - Optimization stopped by user
- **Error** - Optimization stopped due to error.

Status Tables

The objective value table lists the **Best Value** and the **Current Value** for the **Iteration**, whether the best and current values are **Feasible**, and the best and current **Objective Value.**

	Iteration	Feasible	Objective Value
Best Value	2	Yes	34447.3184
Current Value	3	No	29478.7953

The decision variables table lists the decision variables (**Parameters**) included in the optimization. The **Lower Bound**, **Best Value**, **Current Value**, and **Upper Bound** are displayed.

Parameter	Lower Bound	Best Value	Current Value	Upper Bound
Model.NumProdAPersonnel	1	1	3	10
Model.NumProdBPersonnel	1	2	3	10
Model.NumProdCPersonnel	1	7	4	10

The performance measure constraints table lists the performance measures identified as constraints for the optimization. The **Lower Bound**, **Best Value**, **Current Value**, and **Upper Bound** are displayed.

Constraint	Lower Bound	Best Value	Current Value	Upper Bound
TotalWait:Value	-infinity	7.5497	7.5497	30.0

The expression constraint table lists the expression constraints defined for the optimization. The name, not the expression itself, is displayed in the **Expression Constraint** column. The other columns are **Best LF**, **Current LF**, **Best UF**, and **Current UF**. **LF** stands for **Lower Feasibility**, and **UF** stands for **Upper Feasibility**. Feasibility is a measure of how well the constraint was satisfied. A negative number indicates infeasibility. A value of `-infinity` means the constraint was unbounded on the lower side, and a value of `infinity` means the constraint was unbounded on the upper side. For instance, the **Best LF**, **Current LF**, **Best UF**, and **Current UF** of the first expression constraint are 0.0. This means the constraint

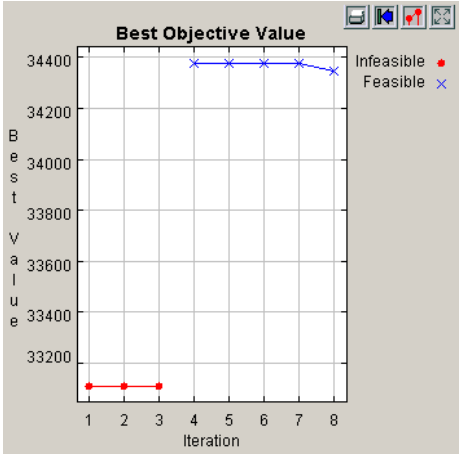
was feasible and was satisfied exactly. Notice that the **Best Value** column and the **Current Value** column of the decision variable table sum to 10.

Expression Constraint	Best LF	Current LF	Best UF	Current UF
Resources = 10	0.0	0.0	0.0	0.0
A <= B	-infinity	-infinity	1.0	1.0
B <= C	-infinity	-infinity	5.0	5.0

Objective Graph

The graph of the objective value plots the best objective value for each iteration. Infeasible values are plotted with dots in red, and feasible values are plotted in blue with Xs. In the example below from the Purchasing model, the first three values were infeasible and the remaining feasible. Remember, once the best value is feasible, the best value will not be infeasible again. To zoom in on a portion of the graph, click and drag over the portion of the graph to enlarge. The buttons above the graph do the following:

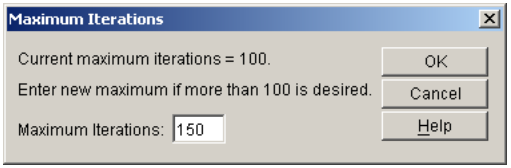
- Print the plot.
- Reset the X and Y ranges to their original (empty plot starting) values.
- Set the plot format.
- Rescale the plot to fit the data. Used after zooming to return to full view of plot.



Maximum Iterations Prompt

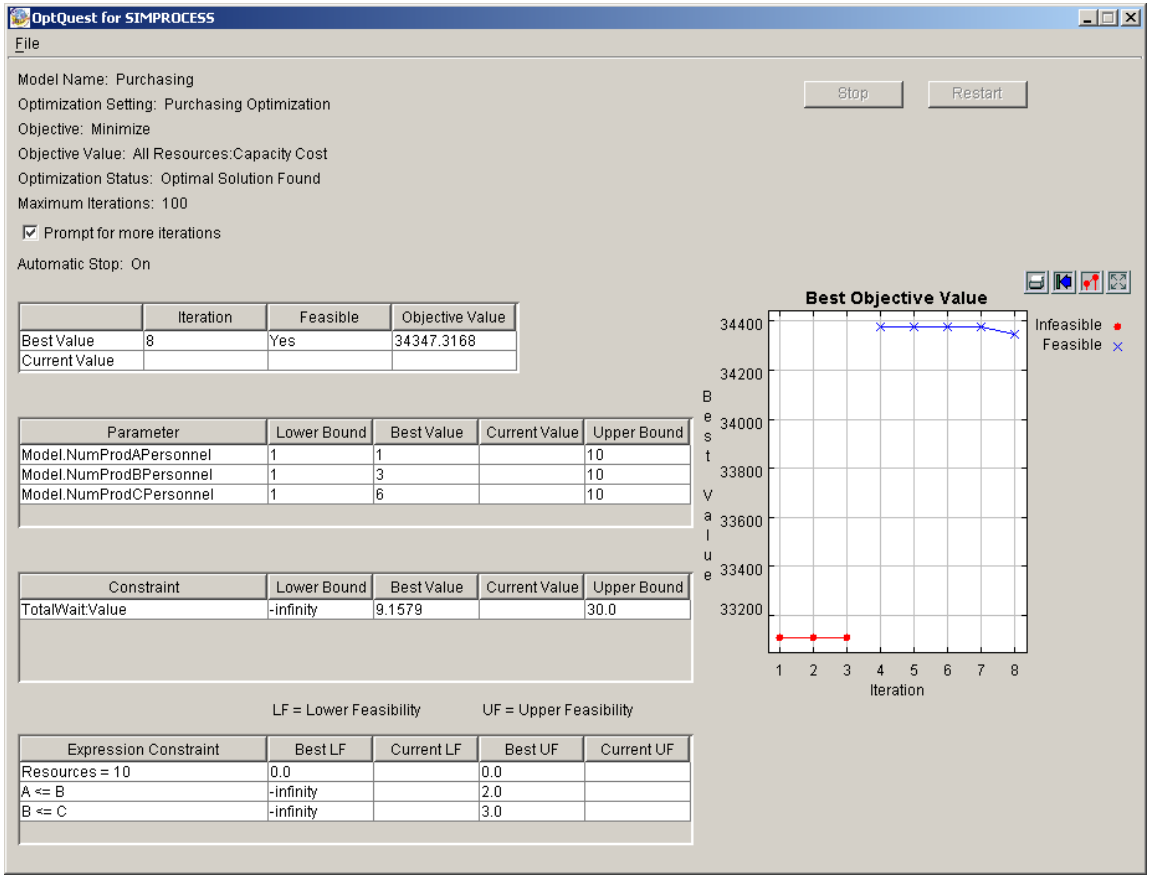
When a maximum number of iterations has been set for the optimization, the checkbox **Prompt for more iterations** is enabled. This checkbox defaults to selected. When selected, the optimization prompts for

more iterations at the end of the next to the last iteration. For instance, if the maximum iterations is set to 100, at the end of iteration 99 the optimization will prompt for a new maximum for the iterations. A new maximum must be entered, not the number of additional iterations. So, for this example, the number entered must be 101 or larger (150 entered). If **Prompt for more iterations** remains selected, the optimization will prompt again when the iteration is one less than the maximum (149 in this example). Deselect this option to have the optimization complete without interruption.

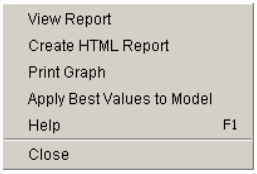


Optimization Solution Options

The OptQuest for SIMPROCESS interface shows the current status of the optimization while it is running. Once the optimization is complete, the interface only shows the best values. The example below is from the Purchasing model.


OptQuest for SIMPROCESS
File
Model Name: Purchasing
Optimization Setting: Purchasing Optimization
Objective: Minimize
Objective Value: All Resources:Capacity Cost
Optimization Status: Optimal Solution Found
Maximum Iterations: 100
Prompt for more iterations
Automatic Stop: On
Stop
Restart
Iteration | Feasible | Objective Value
Best Value | 8 | Yes | 34347.3168
Current Value
Parameter | Lower Bound | Best Value | Current Value | Upper Bound
Model.NumProdAPersonnel | 1 | 1 | | 10
Model.NumProdBPersonnel | 1 | 3 | | 10
Model.NumProdCPersonnel | 1 | 6 | | 10
Constraint | Lower Bound | Best Value | Current Value | Upper Bound
TotalWait:Value | -infinity | 9.1579 | | 30.0
LF = Lower Feasibility
UF = Upper Feasibility
Expression Constraint | Best LF | Current LF | Best UF | Current UF
Resources = 10 | 0.0 | | 0.0 |
A <= B | -infinity | | 2.0 |
B <= C | -infinity | | 3.0 |
Best Objective Value
Infeasible
Feasible
Best Value
34400
34200
34000
33800
33600
33400
33200
1 2 3 4 5 6 7 8
Iteration

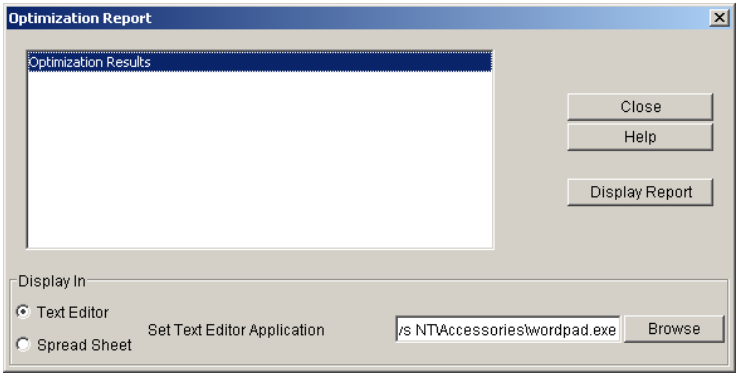
The **File** menu contains other options for examining solutions, and it has an option for applying the best solution to the model. **Help** is also accessed from the **File** menu.



View Report

View Report brings up a dialog similar to the **Standard Report** dialog. With this dialog the report can

be displayed in a text editor or in a spreadsheet.



The report lists the name of the model, the start date/time and end date/time of the optimization, the optimization settings, and the best values for the objective, decision variables, and constraints.

Create HTML Report

This option creates the same report as View Report. However, since it is an HTML file, the objective graph is included as well.

Print Graph

This option sends the objective graph to the selected printer.

Apply Best Values to Model

Apply Best Values to Model assigns the best values from the decision variables to the model parameters in the model. Thus, when the model is reopened in SIMPROCESS, and run is selected, the run values for the model parameters reflect the best values from the optimization. Also, if **OptQuest** is selected again, the starting values for the decision variables are the best values from the optimization.

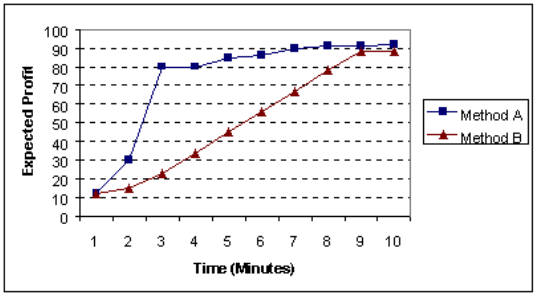
Tips and Suggestions

Search Methodology

There are many factors that influence the performance of OptQuest. For example, consider two optimization methods, A and B, applied to a problem with the objective of maximizing expected returns. When evaluating the performance of each method, consider which method satisfies the following criteria:

- Finds a solution with a larger expected return
- Jumps to the range of high-quality solutions faster

Below is the Performance Graph for the two hypothetical methods.



The figure above shows that, although both methods find solutions with a similar expected profit after 10 minutes of searching, method A jumps to the range of high-quality solutions faster than B. For the criteria listed above, method A performs better than method B.

OptQuest will obtain performance profiles similar to method A. OptQuest's search methodology is very aggressive and attempts to immediately find high-quality solutions, causing large improvements, (with respect to the initial solution), early in the search. This is critical when OptQuest can perform only a limited number of simulations.

However, several factors affect OptQuest's performance, and the importance of these factors varies from one situation to another. This section reviews these factors and offers tips and suggestions on how to achieve maximum performance.

Factors that affect search performance

Any heuristic method for solving problems cannot guarantee that it will find the optimal solution. It

might only find a solution that is close to the optimal solution, usually referred to as the best solution; this is why maximizing performance is critical.

The following is a list of relevant factors that directly affect search performance. Each factor is explained in sections after the list.

- Number of decision variables
- Initial values
- Decision variable bounds
- Complexity of the objective
- Constraints
- Feasibility
- Number of replications and simulations
- Simulation accuracy
- Simulation speed

Number of Decision Variables

The number of decision variables greatly affects OptQuest's performance. OptQuest has no physical limit on the number of decision variables that can be used in any given problem. However, the performance might deteriorate if more than 100 decision variables are used.

Also, as the number of decision variables increases, more simulations are needed to find high-quality solutions. General guidelines for the minimum number of simulations required for a given number of decision variables in a problem are:

Decision Variables	**Minimum number of simulations**
Less than 10	100
Between 10 and 20	500
Between 20 and 50	2,000
Between 50 and 100	5,000

For very large numbers of decision variables, try this procedure:

- Decrease the number of replication per simulation, at least initially
- Run the optimization to get an approximate solution
- Set the suggested values to the approximate solution
- Further restrict the bounds on the decision variables

- Increase the number of replications to increase accuracy
- Rerun the optimization

One option is to de-select certain decision variables and optimize the rest. If an optimization has already been run, there might be information available about which decision variables have the least effect on the objective function. When one or more decision variables is de-selected and the optimization is rerun, the search focuses on the remaining, more important, decision variables.

Initial Values

The initial values are the values listed as the **Starting Values** of the **Decision Variables** tab. Initial values are important because the closer they are to the optimal value, the faster OptQuest can find the optimal solution. If the initial values are constraint-infeasible, they are ignored.

For potentially large models with many decision variables, it might be helpful to first run a simplified version of the optimization to find initial values for the full-blown model. For example, expected values could be used for some of the random variables in the model.

Decision Variable Bounds

OptQuest's performance can be significantly improved by selecting meaningful bounds for the decision variables. Suppose, for example, that the bounds for three decision variables (X, Y, and Z) are:

```
0 <= X <= 100
0 <= Y <= 100
0 <= Z <= 100
```

And in addition to the bounds, there is the following constraint:

```
10*X + 12*Y + 20*Z <= 200
```

Although the optimization model is correct, the decision variables bounds are not meaningful. A better set of bounds for these decision variables would be:

```
0 <= X <= 20
0 <= Y <= 16.667
0 <= Z <= 10
```

These bounds take into consideration the values of the coefficients and the constraint limit to determine the maximum value for each decision variable. The new "tighter" bounds result in a more efficient search for the optimal values of the decision variables. However, this efficiency comes at the expense of missing the optimal solution if it lies outside the specified bounds.

Complexity of the Objective

A complex objective has a highly nonlinear surface with many local minimum and maximum points.

OptQuest is designed to find global solutions for all types of objectives, especially complex objectives. However, for more complex objectives, generally it is required to run more simulations to find high-quality global solutions.

Since only one value can be optimized, complex objectives must be defined within the model expressions. (See “Customizing a Model with Attributes and Expressions” on page 210.)

Constraints

Constraints can be used to restrict the values of decision variables (model parameters) by defining relationships among the decision variables; constraints can also restrict the value of output variables (performance measures).

If a constraint is defined using only decision variables, OptQuest can eliminate sets of decision variables values that are constraint-infeasible before it runs the simulation. Limiting the optimization by defining constraints on decision variables is extremely time-effective.

If a constraint contains a performance measure, a simulation must be run to determine whether the suggested solution satisfies the constraint.

The search process benefits from the use of constraints on decision variables and tight bounds on decision variables. However, performance generally suffers when performance measure constraints are included in the optimization model for two reasons:

- Performance measure constraints are very time-consuming to evaluate, since OptQuest must run an entire simulation before determining whether the results are constraint-infeasible.
- To avoid running constraint-infeasible simulations, OptQuest must identify the characteristics of solutions likely to be constraint-feasible; this makes the search more complex and requires more time.

Even though performance measure constraints can greatly decrease the number of feasible simulations performed during an optimization, performance measure constraints can focus the search to effectively rule out undesirable solutions.

If there are lots of performance measure constraints that OptQuest can't easily satisfy, consider combining the output constraints into one multi-objective function.

Feasibility

OptQuest makes finding a feasible solution its highest priority. Once it finds a feasible solution, it then

concentrates on finding better solutions.

The fact that a particular solution may be infeasible does not imply that the problem itself is infeasible. However, infeasible problems do exist. For example, suppose that in a Job Shop problem a foreman insists on finding an optimal configuration with the following constraints:

```
drills + grinders <= 4
drills + grinders >= 5
```

Clearly, there is no combination that will satisfy both of these constraints.

Or, for this same example, suppose the bounds for a decision variable were:

```
3 <= saws <= 5
```

And a constraint was:

```
saws <= 2
```

This also results in an infeasible problem. OptQuest will display an error message and terminate infeasible optimizations.

Infeasible problems can be made feasible by fixing the inconsistencies of the relationships modeled by the constraints. OptQuest detects optimization models that are constraint-infeasible and reports them.

If a model is constraint-feasible, OptQuest will always find a feasible solution and search for the optimal solution (i.e., the best solution that satisfies all constraints).

Number of Replications and Simulations

When OptQuest runs an optimization, it runs a simulation to evaluate each set of decision variable (model parameter) values. Therefore, the quality of the optimization results depends on the number of simulations (iterations) and the number of replications per simulation.

For a set period of time, the number of replications per simulation is inversely related to the number of simulations; as one increases, the other decreases. Decreasing the number of replications can help increase the number of simulations.

The more simulations OptQuest can run, the more sets of values it can evaluate, and the more likely OptQuest is to find a solution close to the optimal solution.

Simulation Accuracy

There are two factors that affect simulation accuracy:

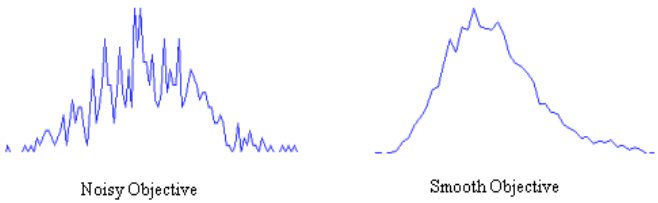
- Number of replications per simulation
- Noisiness of the objective

Number of replications per simulation

For sufficient accuracy, the number of replications per simulation must be set to the minimum number necessary to obtain a reliable estimate of the objective function being optimized; this minimum number is typically found with empirical testing.

Objective noisiness

Noisiness can also affect the accuracy of OptQuest results.



The objective on the left has significant amounts of noise caused by the probability distributions used to model the problem's uncertainty. For these types of objectives, OptQuest might have trouble discerning the minimum or maximum value. Noisy functions can be detected by watching for best solutions that seem to "bounce around" from one set of values to completely different sets of values. To help solve this problem, increase the number of replications per simulation. On the right, the objective appears smooth due to the relative certainty in the model assumptions. In these cases, OptQuest should quickly converge to the best solution.

Simulation Speed

Some suggestions for increasing speed include:

- Reduce the size of the model (or the time horizon of the simulation).
- Increase the system's RAM memory.
- Reduce the number of uncertain elements in the simulation.
- Close other applications.

OptQuest Demonstration Models

Two of the demonstration models that come with SIMPROCESS have been set up for optimization: the Purchasing model (Purchasing.spm) and the Inventory model (Inventory.spm).

Purchasing Model

This model was used throughout this chapter to describe how to set up and run an OptQuest optimization. Thus, an extended description will not be given here. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*. The optimization set up for this model should not be considered a true optimization scenario. The constraints are very tight, and the number of replications per simulation is only two. This was done so the example would run within a minute or two. The value of this model is in learning how to create decision variables and constraints.

Inventory Model

This model was developed for the purpose of finding optimal values. The model is described in Chapter 5 of the *SIMPROCESS Getting Started Manual*. Briefly, the Inventory model demonstrates an Inventory Pull and Manufacturing system. The process is characterized by the Reorder Points and Reorder Quantities defined for each resource in the supply chain. There are four steps in the supply chain: Warehouse, Assembly, Component1 Vendor and Component2 Vendor, and the Raw Material Vendors. Inventory is pulled only when it is needed (there is insufficient stock to fill the order or the Reorder Point has been reached). There are 10 Model Attributes in the model that have been designated as model parameters.

- Comp1ReOrderPt - Component Vendor 1 (Comp1 resource) Reorder Point
- Comp1ReOrderQty - Component Vendor 1 (Comp1 resource) Reorder Quantity
- Comp2ReOrderPt - Component Vendor 2 (Comp2 resource) Reorder Point
- Comp2ReOrderQty - Component Vendor 2 (Comp2 resource) Reorder Quantity
- FinProdReOrderPt - Finished Product (FinProduct resource) Reorder Point
- FinProdReOrderQty - Finished Product (FinProduct resource) Reorder Quantity
- Raw1ReOrderPt - Raw Material Vendor 1 (Raw1 resource) Reorder Point
- Raw1ReOrderQty - Raw Material Vendor 1 (Raw1 resource) Reorder Quantity
- Raw2ReOrderPt - Raw Material Vendor 2 (Raw2 resource) Reorder Point
- Raw2ReOrderQty - Raw Material Vendor 2 (Raw2 resource) Reorder Quantity

The goal is to minimize the amount of inventory held without impacting the customer negatively (increase order cycle time). This can be done by finding the optimal Reorder Points and Quantities

for each node in the supply chain. Using OptQuest the optimal Reorder Points and Reorder Quantities can be found. Thus, the decision variables for the optimization are the model parameters, and the default values for the attributes are the **Starting Values** for the decision variables. (See "Decision Variables" on page 355.)

The objective is twofold: minimize inventory (FinProduct resource) and minimize the amount of time it takes to fill a customer order. See "Preparing for Optimization," beginning on page 352 for a discussion on how these dual objectives are combined into one objective.

The performance measure for the amount of inventory and the performance measure for the amount of time it takes to fill a customer order are used as performance measure constraints. These values are obtained using the `GetResourceStatistic` and `GetEntityStatistic` expression statements in the **End Simulation** expression for the model (**Define/Model Expressions**). These values are assigned to Model Attributes, which are used as constraints.

The number of replications per simulation is set to 5, the maximum number of iterations is 100, and the automatic stop feature is turned on with a precision of 0.1.

This optimization takes from 5 to 7 hours to run (possibly longer), depending on system memory and processor speed.

CHAPTER 16

SIMPROCESS Dashboards

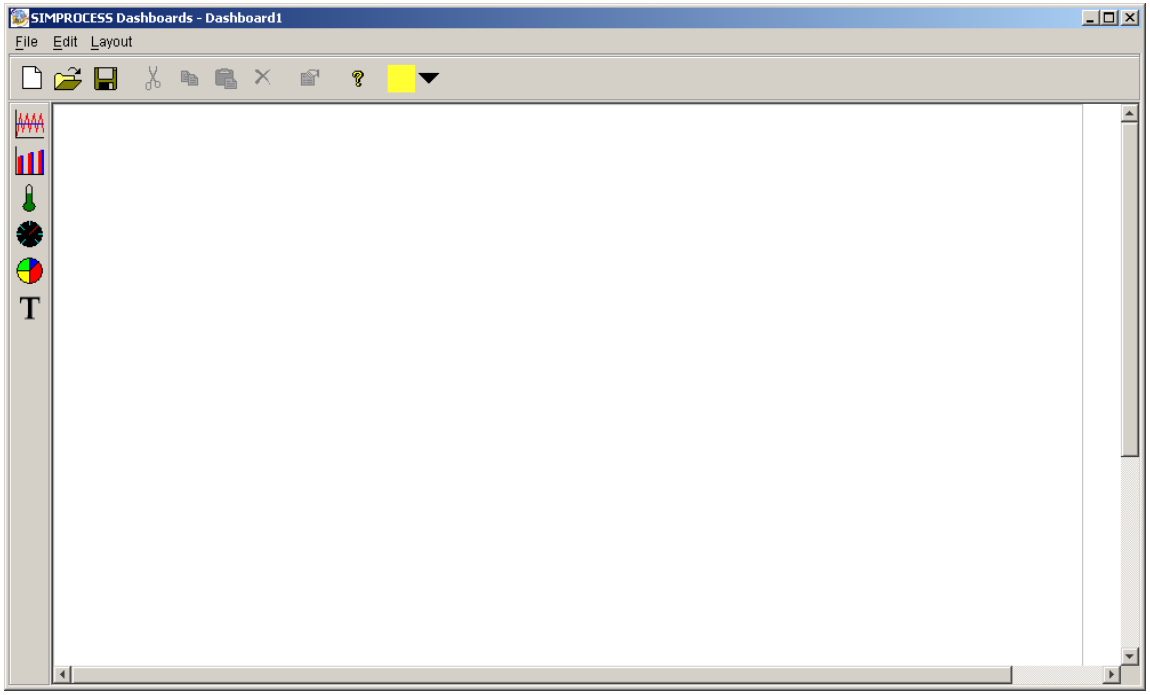
SIMPROCESS Dashboards are collections of dynamic graphs that can be displayed locally or remotely by a Dashboard Server. The graphs contained by Dashboards can be of the same type or of differing types.

Dashboards are defined independent of SIMPROCESS models. Thus, a Dashboard can be used with multiple models, or multiple models may use a single Dashboard. To use a Dashboard with a model, the Dashboard must be Assigned to a model. The Assign process links the Dashboard to the model, indicates the location of the Dashboard Server for display (host or IP address and port), and sets the values that will be displayed on the graphs defined for that Dashboard.

During a simulation, Dashboards can only be displayed by using a Dashboard Server. A copy of the Dashboard file must be located with the Dashboard Server.

Defining Dashboards

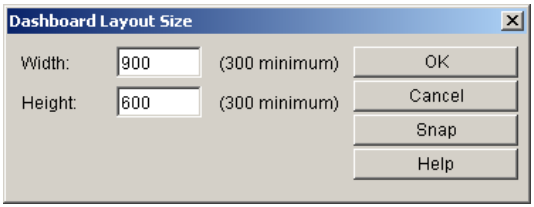
Dashboards are defined independent of SIMPROCESS models. Thus, no model needs to be open to define a Dashboard. The **Report** menu contains a **Dashboard** item with a submenu that has two items: **Define...** and **Assign...**. Selecting **Define...** brings up the SIMPROCESS Dashboard graphical user interface (GUI).



The Dashboard GUI is similar to the SIMPROCESS GUI. The primary differences are that only one Dashboard can be open at a time, and the Dashboard GUI initially opens with an empty Dashboard named **Dashboard1**.

Dashboard Layout

The Dashboard layout is similar to the layout of a SIMPROCESS model in that its size can be set (**Layout/Size** menu item), and its background color can be set (**Layout/Background Color** menu item). Selecting **Layout/Size** brings up the following dialog.



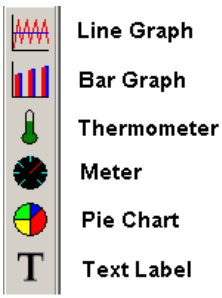
Each Dashboard has a size denoted by a gray line in the editor window. This size, measured in pixels, will be used by the Dashboard Server to build a window in which to display the Dashboard and its Graphs. The width and height values must be at least 300 pixels each but are otherwise unlimited in size. However, when determining the size, consideration should be given to the size of the display on which the server will run when a Dashboard is displayed. The **Snap** button will automatically adjust the width and height values to the smallest values required to contain all Graphs currently in the Dashboard. **Snap** will not resize the layout to smaller than 300 x 300 pixels.

Selecting **Layout/Background Color** sets the color of the layout to the color displayed on the color button on the toolbar. The arrow to the right of the color button brings up a color chooser to select the desired color.

Dashboard Graphs

The toolbar on the left contains the graph types that can be added to the layout. The types of graphs that can be displayed on a Dashboard are

- Line Graph
- Bar Graph (Horizontal or Vertical, 2D or 3D)
- Meter
- Thermometer
- Pie Chart (2D or 3D)
- Text Label



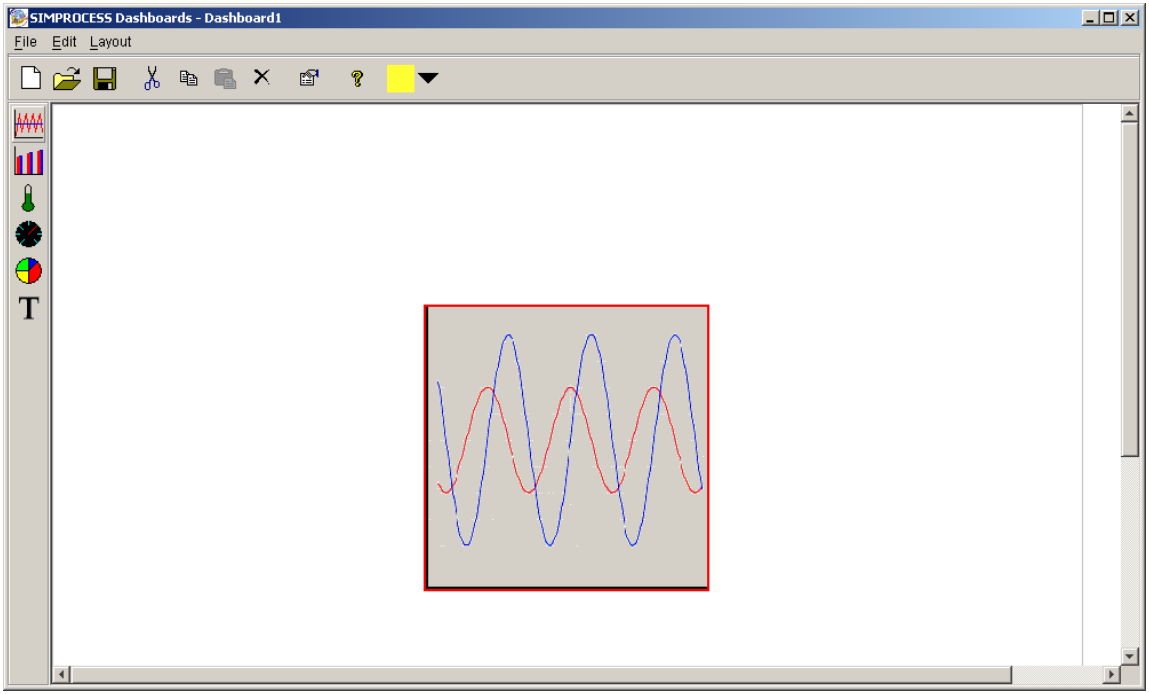
The Line Graph displays one or more X-Y series where the X axis represents simulation time. The Bar Graph displays one or more values. The Thermometer and Meter display one value each. The Pie Chart displays two or more values. The Text Label can be static, or it can display one value dynamically.

Note that the values to be displayed are not assigned while defining Dashboards. The properties that can be set while defining are appearance and

location related properties. The properties set while defining a Dashboard are considered to be the default properties of the Dashboard. Most appearance properties (not location) can be changed when using a Dashboard with a model.

Adding a Graph

Selecting a graph on the graph toolbar causes a new panel that represents a graph of that type to appear in the center of the layout. The graph itself does not appear on the layout. Once on the layout, the graph panel can be moved and resized. Also, actual properties of the graph represented by the graph panel can be set. The new graph panel that is automatically selected. A graph that is selected has a red border around it. Multiple graphs can be selected by holding down the Control key when clicking on graph panels. Multiple graph panels can also be selected by clicking and dragging a selection rectangle around the desired panels.



Moving a Graph

To move a graph, click on the graph panel and drag while holding down the mouse button. Multiple graph panels can be moved simultaneously by selecting multiple graphs before moving. The same type grid that is available for creating SIMPROCESS models is available for Dashboards on the **Layout** menu. However, due to the size of the graph panels, movement can be difficult with the grid turned on.

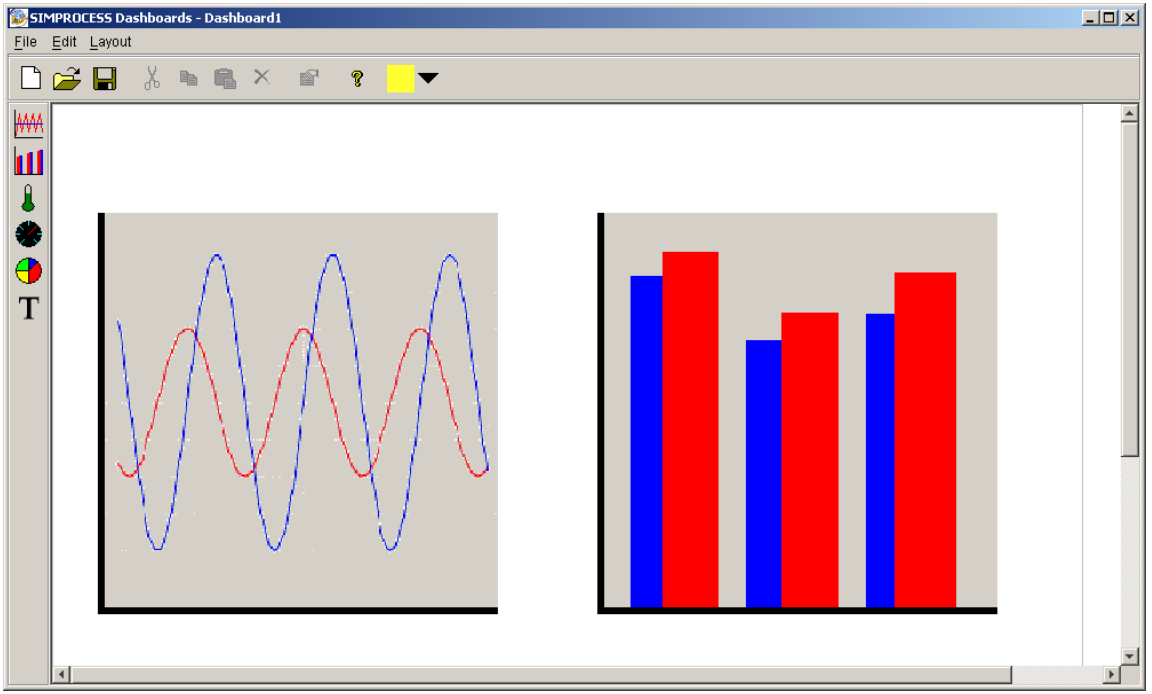
Resizing a Graph

The default size of a graph panel (other than Text Label, which is 250 x 100 pixels) is 250 x 250 pixels. A graph panel can be resized by clicking on the edge of a graph panel and dragging. Also, a specific size can be set by selecting **Edit/Resize** from the menu or by right mouse clicking on the graph panel and choosing **Edit/Resize**. Multiple graph panels can be resized simultaneously by selecting multiple graphs before resizing.

Aligning and Distributing Graphs

When two or more graph panels are selected, they can be aligned using the **Layout/Align** menu item or by right clicking on a selected graph panel and choosing the appropriate align item. When three or more graph panels are selected, they can be distributed horizontally, vertically, or circularly using the **Layout/Distribute** menu item or by right clicking on a selected graph panel and choosing the appropriate distribute item.

The image below shows a Dashboard with a Line Graph and a Bar Graph that have been moved from the center, resized to 350 x 350 pixels, and aligned.



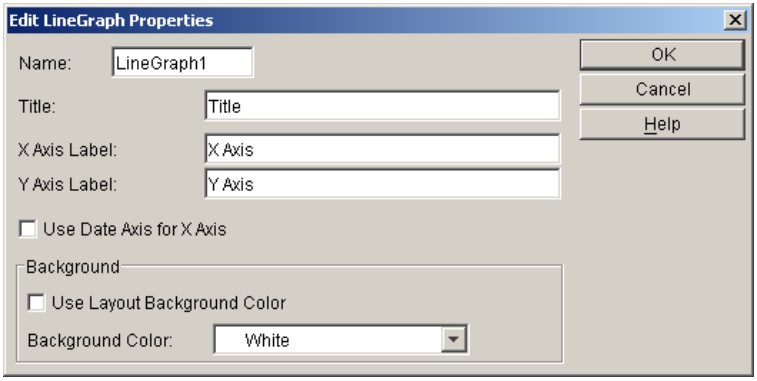
Editing Graph Properties

The default properties for graphs can be edited by double clicking a graph panel, selecting a panel and choosing **Edit/Properties** from the menu, selecting a panel and clicking the properties button on the toolbar, or by right clicking and choosing **Properties**. Properties common to all graphs are **Name** and **Background**. The **Name** is used to identify the graph to the Dashboard and must be unique. **Background** sets the color of the background or the graph. A specific color can be selected from the **Background Color** list, or **Use Layout Background Color** can be selected. **Use Layout Background Color** sets the background color of the graph to background color of the layout. Note that **Name** and **Background** cannot be changed when a Dashboard is assigned to a model.

Line Graph Properties

Title, **X Axis**, **Y Axis**, and **Use Date Axis for X Axis** are additional properties for the Line Graph. These default properties can be overridden when the Dashboard is assigned to a model.

- **Title** - default title for the Line Graph
- **X Axis** - label for the x axis
- **Y Axis** - label for the y axis
- **Use Date Axis for X Axis** - if selected, the x axis displays times and dates instead of a number

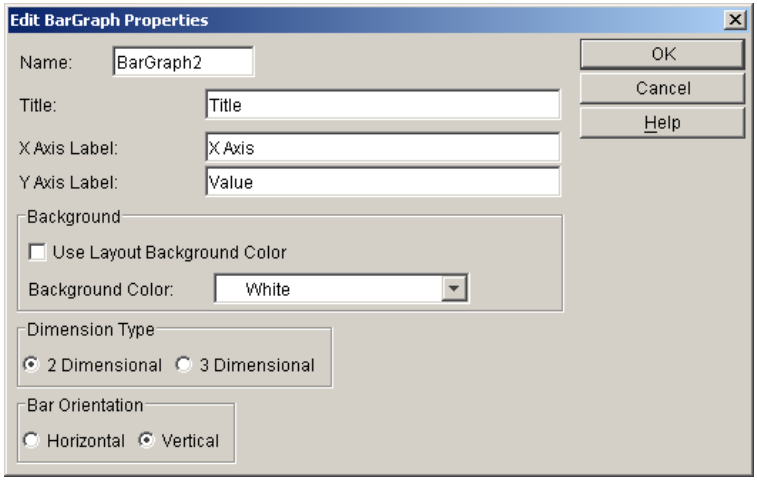


Bar Graph Properties

Title, **X Axis**, **Y Axis**, **Dimension Type**, and **Bar Orientation** are additional properties for the Bar Graph. These default properties can be overridden when the Dashboard is assigned to a model.

- **Title** - default title for the Bar Graph
- **X Axis** - label for the x axis
- **Y Axis** - label for the y axis
- **Dimension Type** - **2 Dimensional** or **3 Dimensional**

- **Bar Orientation** - **Horizontal** or **Vertical**

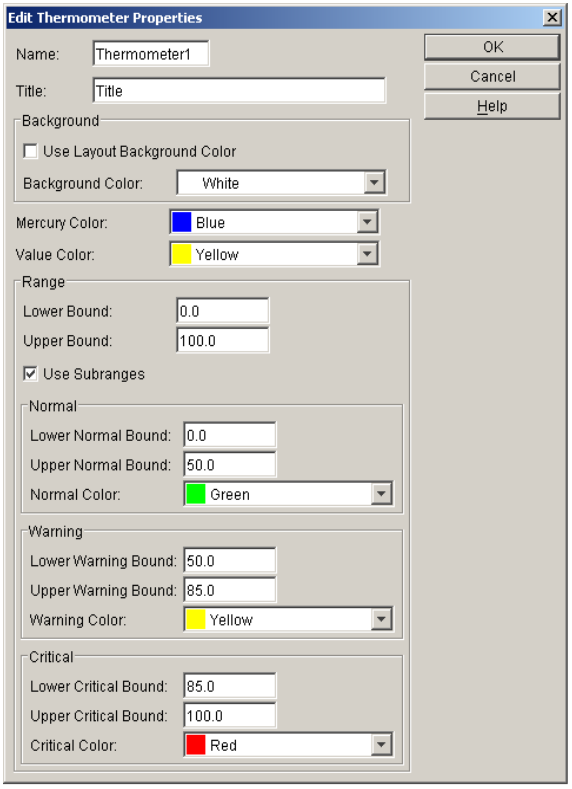


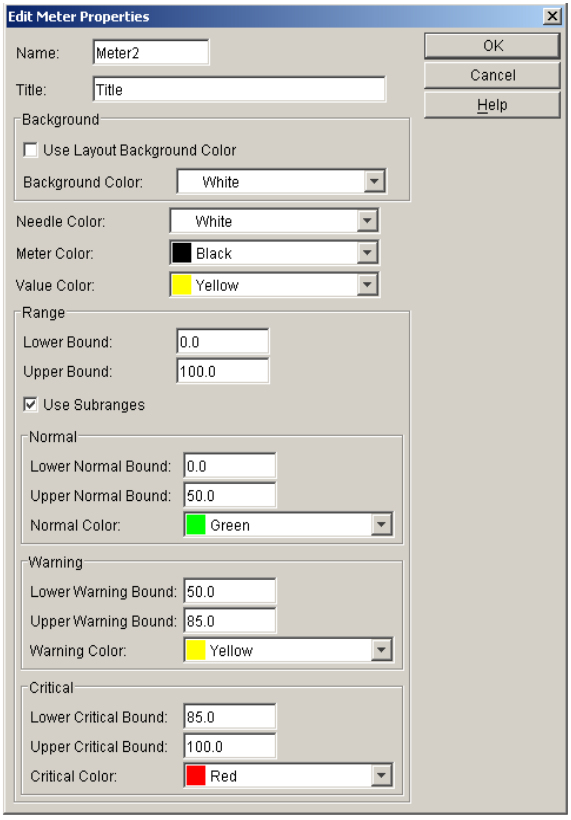
Meter and Thermometer Properties

The Meter and Thermometer have similar properties. Both have a **Title**, a **Range** with optional sub ranges, and a **Value Color**. The differences are in the other color options. The Meter has a **Needle Color** and a **Meter Color** option. The Thermometer has a **Mercury Color** option.

- **Title** - default title for the Meter or Thermometer
- **Mercury Color** - default color for the mercury in the Thermometer
- **Needle Color** - default color for the needle on the Meter
- **Meter Color** - default color for the Meter
- **Value Color** - default color for the current value of the Meter or Thermometer
- **Lower Bound** - default lower bound for the Meter or Thermometer
- **Upper Bound** - default upper bound for the Meter or Thermometer
- **Use Subranges** - if selected, lower bounds, upper bounds, and colors for three subranges (**Normal**, **Warning**, and **Critical**) can be set. If subranges are used for the Thermometer, the colors selected for the subranges override the **Mercury Color** setting.
- **Lower Normal Bound** - default lower bound for the **Normal** sub range
- **Upper Normal Bound** - default upper bound for the **Normal** sub range
- **Normal Color** - default color for the **Normal** sub range
- **Lower Warning Bound** - default lower bound for the **Warning** sub range
- **Upper Warning Bound** - default upper bound for the **Warning** sub range
- **Warning Color** - default color for the **Warning** sub range

- **Lower Critical Bound** - default lower bound for the **Critical** sub range
- **Upper Critical Bound** - default upper bound for the **Critical** sub range
- **Critical Color** - default color for the **Critical** sub range

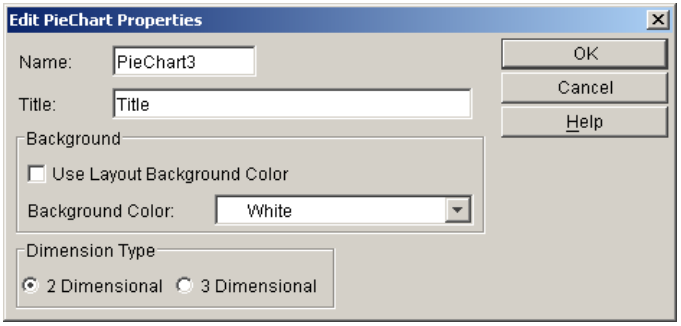




Pie Chart Properties

Title and **Dimension Type** are additional properties for the Pie Chart. These default properties can be overridden when the Dashboard is assigned to a model.

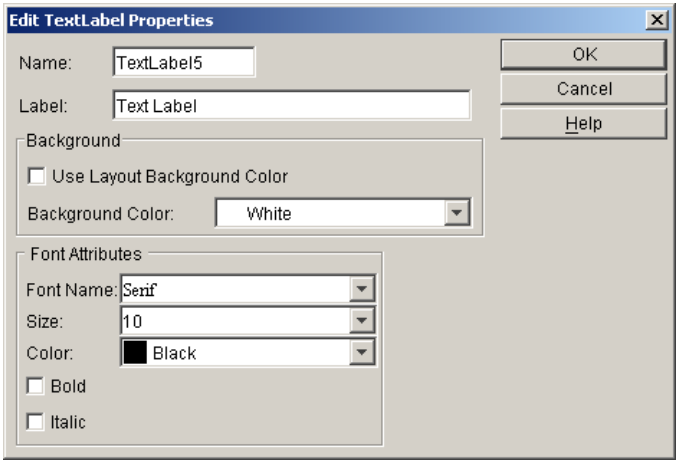
- **Title** - default title for the Pie Chart
- **Dimension Type** - **2 Dimensional** or **3 Dimensional**



Text Label Properties

Text Label properties include **Label** and **Font Attributes,** which include **Font Name**, **Size**, **Color**, **Bold**, and **Italic.**

- **Label** - default text that is displayed
- **Font Name** - default font for label
- **Size** - default font size for label
- **Color** - default font color for label
- **Bold** - default selection for bold
- **Italic** - default selection for italic



Dashboard Menus

File Menu

New places a new Dashboard in the work area displayed in the window. If the current Dashboard has been changed, SIMPROCESS will prompt to save its contents to a file before clearing it in favor of a new Dashboard in the work area.

Open prompts for the selection of a Dashboard file (having the extension ".spd"), which will be read and displayed in the work area. If the current Dashboard has been changed, SIMPROCESS will prompt to save its contents to a file before clearing it in favor of a new Dashboard created from the selected file.

Save saves the current work area into its Dashboard file. If no file has yet been associated with it, this behaves the same as **Save As**.

Save As saves the current Dashboard to a new file. If an existing file is selected, SIMPROCESS will question whether to overwrite that file.

Preview will be enabled when the Dashboard in the work area contains one or more Graphs. It will open a separate window with the specified layout size (**Layout/Size**) containing actual sample graphs configured with the properties set in each graph panel. This is how the actual Dashboard will look when shown by a Dashboard Server.

Close closes the SIMPROCESS Dashboards window. If the current Dashboard has been changed, SIMPROCESS will prompt to save those changes.

Edit Menu

Cut is enabled only if one or more Graphs are selected (as indicated by a red border). **Cut** removes the selected Graphs from the layout and places them onto the clipboard, where they may later be pasted back into the current or a different Dashboard.

Copy is enabled only if one or more Graphs are selected (as indicated by a red border). **Copy** places a copy of the selected Graphs onto the clipboard, where they may later be pasted back into the current or a different Dashboard.

Paste is enabled only if one or more Graphs has been placed (via **Cut** or **Copy**) onto the clipboard. **Paste** places Graphs from the clipboard onto the layout. The clipboard's contents remain intact until changed by a subsequent **Cut** or **Copy** action.

Duplicate is enabled only if one or more Graphs are selected (as indicated by a red border). **Duplicate** acts as though **Copy** was selected followed by **Paste.** That is, it copies all selected Graphs onto the clipboard and then immediately pastes them back into the current layout.

Clear is enabled only if one or more Graphs are selected (as indicated by a red border). **Clear** removes

the selected Graphs from the layout and does not place them onto the clipboard.

Select All is enabled only if one or more Graphs appear on the layout. Select All selects all Graphs on the layout and displays red borders to indicate their selected status.

Resize is enabled only if one or more Graphs are selected (as indicated by a red border). **Resize** presents a Resize dialog where the width and height of the selected Graphs are specified in pixels. If more than one Graph is selected, the size entered will be applied to all of them. Individual Graphs may also be resized by selecting them and moving the mouse cursor over a portion of the border, then dragging when the cursor changes to indicate the direction of the resizing operation.

Properties is enabled only if one or more Graphs are selected (as indicated by a red border). **Properties** presents a Graph Properties dialog for each selected Graph in turn. Properties can also be edited by double-clicking any Graph, clicking the properties button on the toolbar, or right clicking and choosing **Properties**.

Layout Menu

Size is always enabled since a Dashboard is considered to be open in the work area at all times. **Size** displays the Dashboard Layout Size dialog.

Background Color is always enabled since a Dashboard is considered to be open in the work area at all times. **Background Color** sets the background color of the Dashboard layout to the currently selected color on the Dashboard Color button on the toolbar.

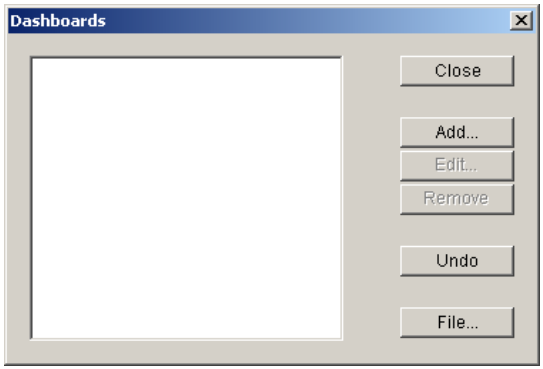
Align is enabled only if two or more Graphs are selected (as indicated by a red border). **Align** presents a dialog with **Top**, **Bottom**, **Left**, **Right**, **Center (Vertical)** and **Center (Horizontal)**. Selected Graphs will be repositioned so that they align as directed. Alignment can also be set by right clicking on a selected Graph.

Distribute is enabled only if three or more Graphs are selected (as indicated by a red border). **Distribute** presents a dialog with **Vertically, Horizontally** and **Circular**. Selected Graphs will be repositioned so that they are distributed within the available space (the layout size) as directed, much like the equivalent function in the SIMPROCESS model editor. Selected Graphs can also be distributed by right clicking on a selected Graph.

Snap to Grid, **Grid Lines**, **Grid Spacing**, and **Grid Color** work like their counterparts in the SIMPROCESS model editor. They allow the optional use of grid lines to help in placement of Graphs in a Dashboard. However, due to the size of graph panels, movement is difficult with grid lines turned on.

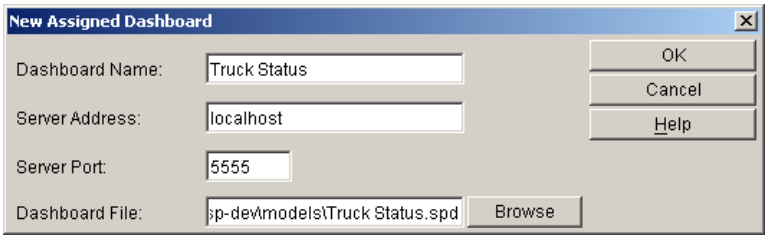
Assigning Dashboards

To assign a Dashboard to a model, select **Dashboard/Assign...** from the **Report** menu. For the **Assign...** menu item to be active, a SIMPROCESS model must be open, and the Dashboard GUI must be closed. **Assign...** brings up a list of the Dashboards assigned to the model. Use the **File...** button to update the Dashboard file's location if the Dashboard was developed on a different system or moved to a location other than where it was located when originally assigned.



Adding a Dashboard Assignment

Dashboards are assigned to a model by using the **Add...** button on the Dashboard list dialog. The New Assigned Dashboard Dialog has four fields: **Dashboard Name**, **Server Address**, **Server Port**, and **Dashboard File**. The **Dashboard Name** defaults to "Dashboard" plus an internally assigned number. This name can be changed to something more meaningful. The **Server Address** defaults to localhost (which refers to the same machine on which SIMPROCESS is running), and **Server Port** defaults to 5555. If not using localhost for the **Server Address**, the **Server Address** must be a fully qualified server name or an Internet Protocol (IP) address. Use the **Browse** button to locate the **Dashboard File** that is to be displayed. (**TIP:** Whenever practical, the file should be in the same directory with the SIMPROCESS model, or in a directory below the one where the SIMPROCESS model resides. This allows the stored reference to be relative, so that moving both the SIMPROCESS model and the Dashboard file to a new location where their relative positions are unchanged will still maintain a correct reference.) Note that **Add...** does not complete the assignment of a Dashboard to a model. The Graphs must be edited as described below to customize the way they appear and plot values to them.

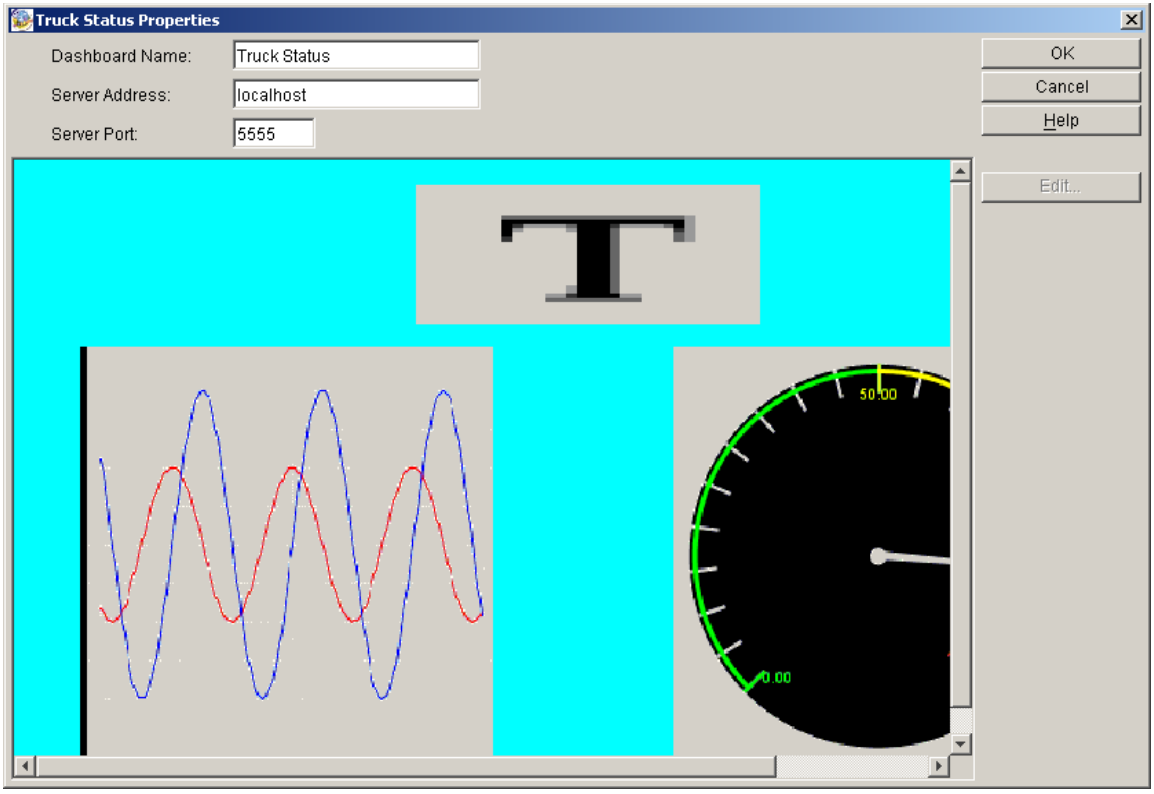


Editing and Removing a Dashboard Assignment

Selecting a Dashboard assignment in the list causes the **Edit** and **Remove** buttons to activate.

Remove removes the Dashboard assignment from the model. A Dashboard assignment that has been removed can be restored with the **Undo** button. **Edit** displays a Dashboard Edit dialog that allows customization of the Dashboard for the model and assignment of plot values to any of the graphs on the Dashboard. The **File** button presents a dialog that allows selecting the Dashboard file for the selected Dashboard assignment and should normally only be needed if its location has changed.

The properties dialog contains three fields that can be edited: **Dashboard Name**, **Server Address**, and **Server Port**. Below those fields is a view of the Dashboard that was assigned to the model. The example below contains a Text Label, Line Graph, and Meter.

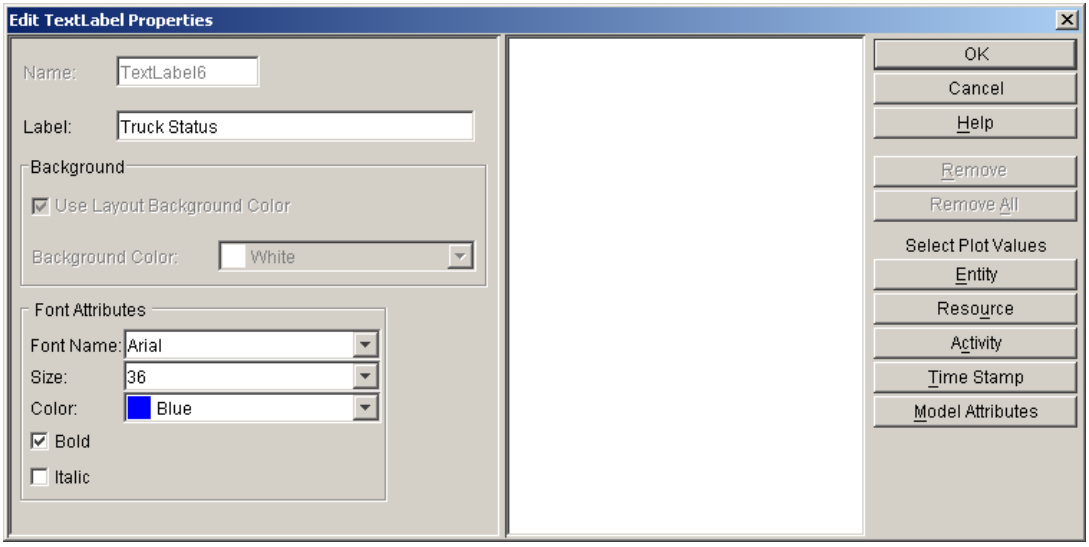


Selecting a Graph causes the **Edit** button to activate. **Edit** displays a dialog with the default properties of the Graph. The Graph properties can also be accessed by double clicking the Graph. These properties (other than **Name** and **Background**) can be customized for the model. Also, the values to be plotted are added to the Graph.

Customizing Properties

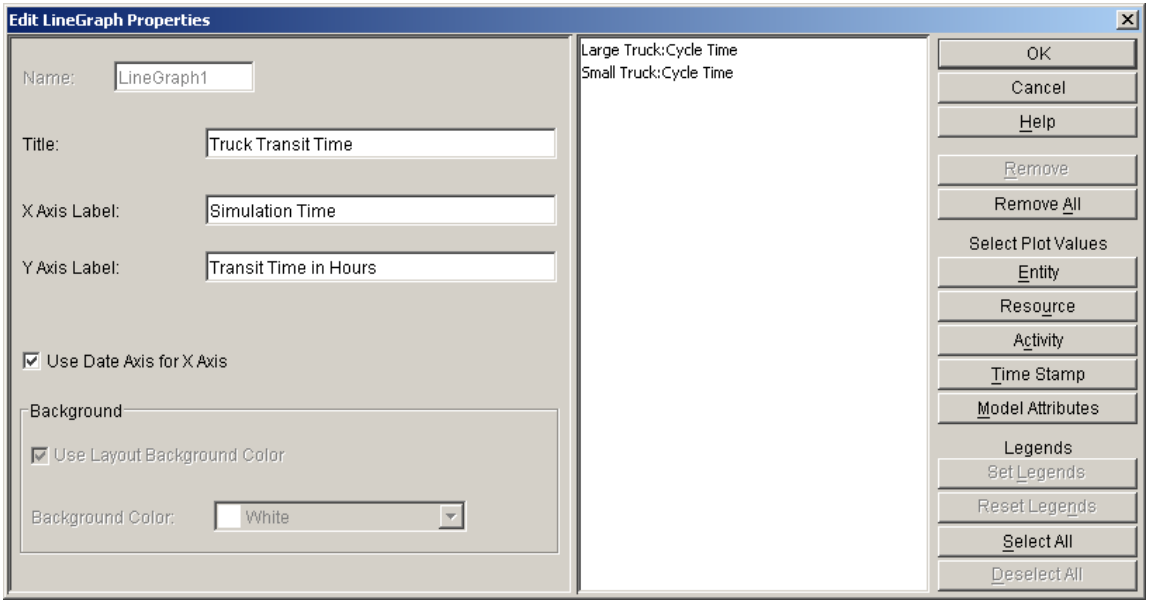
Editing the Text Label brings up the dialog below. The left side of the dialog contains the same properties that are editable when defining Dashboards. Note that **Name** and **Background** cannot be changed. Any changes made in this dialog will override the default properties in the Dashboard file when the Dashboard is displayed. The properties of the other Graphs are customized in the same manner. The right side of the dialog contains the value to display. Since the right side is empty, this Text Label is a static label. Although Text Labels can display one value dynamically, they are best used as static labels. (**Important Note:** If you are planning to have multiple models referring to the same Dashboard while it is displayed, you can prevent any Graphs your model does not use from receiving an initialization message at simulation time which could change their appearance at the

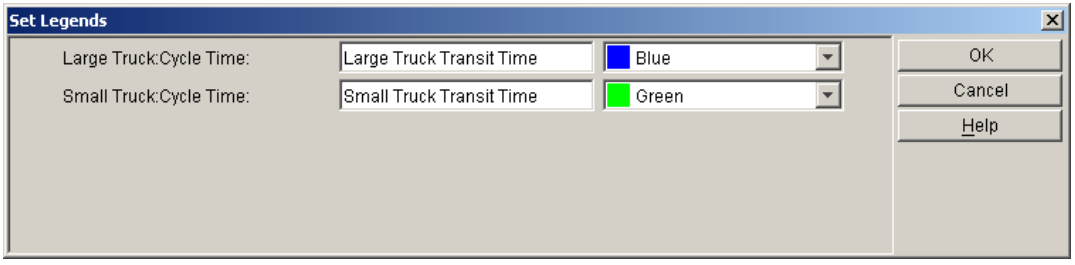
Dashboard Server. For a Text Label, make sure the **Label** value is empty and do not select any plot values. For all other Graphs, do not select any plot values.) Adding values to Graphs is discussed below.



Adding Values to a Graph

Values are added to a graph using the buttons under the **Select Plot Values** heading (**Entity**, **Resource**, **Activity**, **Time Stamp**, and **Model Attribute**). The procedure for adding values is the same as for Custom Plots. See "Adding Values To Custom Plot," beginning on page 185 for detailed instructions on adding values. The Line Graph, Bar Graph, and Pie Chart can plot multiple values. The Meter, Thermometer, and Text Label can only plot one value. The Line Graph, Bar Graph, and Pie Chart also allow the text and color of the legend to be set. The Thermometer allows the text of the legend to be set, but not the color. This is because the color is set in the Thermometer properties. The procedure for setting legends is the same as for Custom Plots. See "Setting Legends," beginning on page 193 for detailed instructions on setting legends. The images below show the properties of the Line Graph with the legend setting below that.

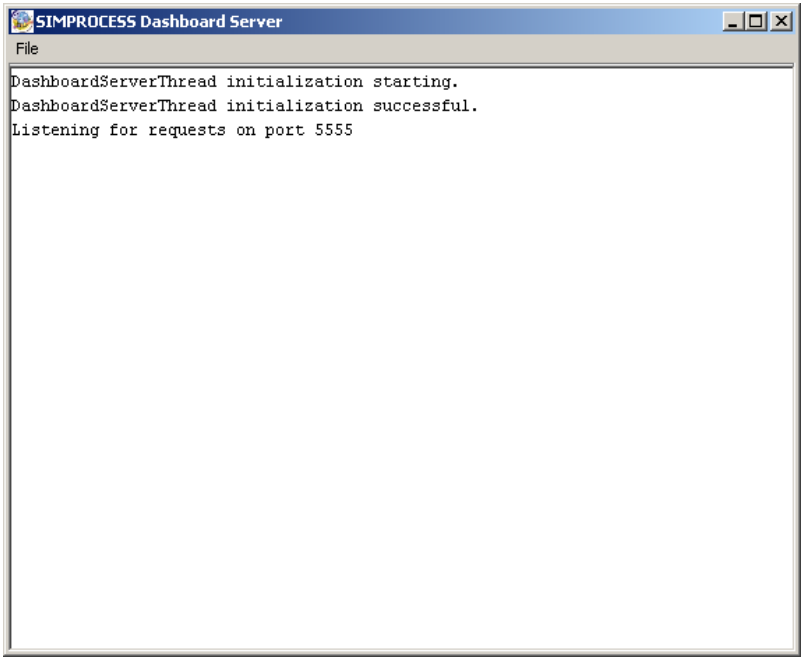

Edit LineGraph Properties
Name:
LineGraph1
Title:
Truck Transit Time
X Axis Label:
Simulation Time
Y Axis Label:
Transit Time in Hours
Use Date Axis for X Axis
Background
Use Layout Background Color
Background Color:
White
Large Truck:Cycle Time
Small Truck:Cycle Time
OK
Cancel
Help
Remove
Remove All
Select Plot Values
Entity
Resource
Activity
Time Stamp
Model Attributes
Legends
Set Legends
Reset Legends
Select All
Deselect All


Set Legends
Large Truck:Cycle Time:
Large Truck Transit Time
Blue
Small Truck:Cycle Time:
Small Truck Transit Time
Green
OK
Cancel
Help

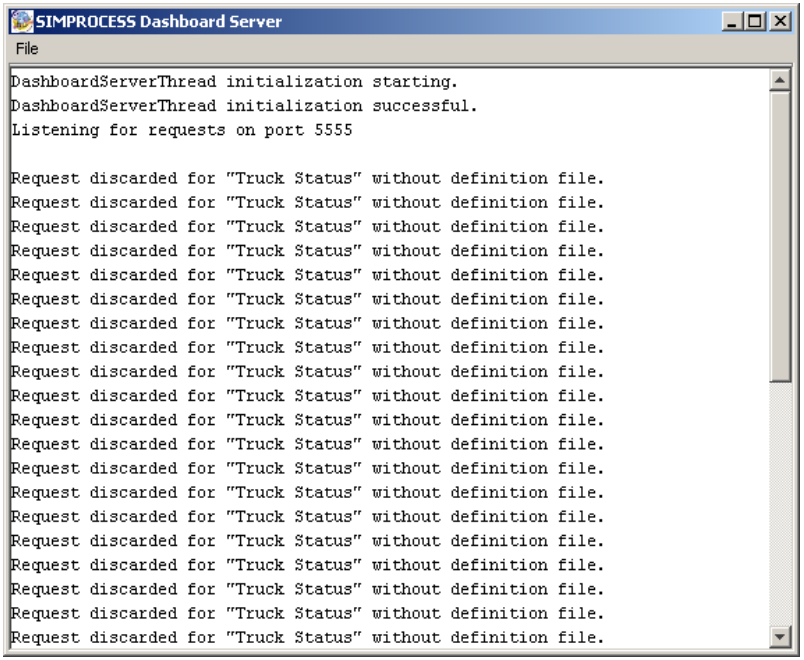
Displaying Dashboards

Dashboards are displayed by a Dashboard Server. A directory named `dashboardserver` is located in the SIMPROCESS directory. A copy of the contents of this directory must be located on each system that is to run a Dashboard Server. Within the `dashboardserver` directory is a directory named `dashboards`. A copy of the Dashboard files (`.spd` files) assigned to the model must be placed in the `dashboards` directory used by a Dashboard Server for it to be displayed. To use a directory other than `dashboards`, modify the `server.properties` file to reference the alternate directory. The port for the Dashboard Server can also be changed in this file. Multiple Dashboard Servers on the same system can use the same `dashboards` directory, but they must have different ports. **Note:** There is one exception to this last item. Multiple Dashboard Servers on one system may listen on the same port if subscribing to multicast groups, even if all subscribe to the same one.

If there are multiple Dashboard assignments in the model with different server addresses and/or ports, a Dashboard Server must be started on each **Server Address** and **Server Port** referenced (or subscribe to the multicast group). If the **Server Address** for any assigned Dashboards is `localhost`, a Dashboard Server can be started from SIMPROCESS by selecting **Tools/Remote/Start Local Dashboard Server**. On Windows, the `server.bat` file can be used to start a Dashboard Server. The `server.sh` file is for Linux systems, though it will also work on other Unix systems. Note that these files specify a path to the JRE installed with SIMPROCESS. If the system does not have a version 1.4 or later JRE, the JRE installed with SIMPROCESS (in the `jre` directory) can be copied if it has the same or a compatible operating system, or a JRE can be downloaded from java.sun.com for most platforms, or from the appropriate vendor for others. The Dashboard Server must be initialized before the simulation begins. When started, the Dashboard Server window appears.



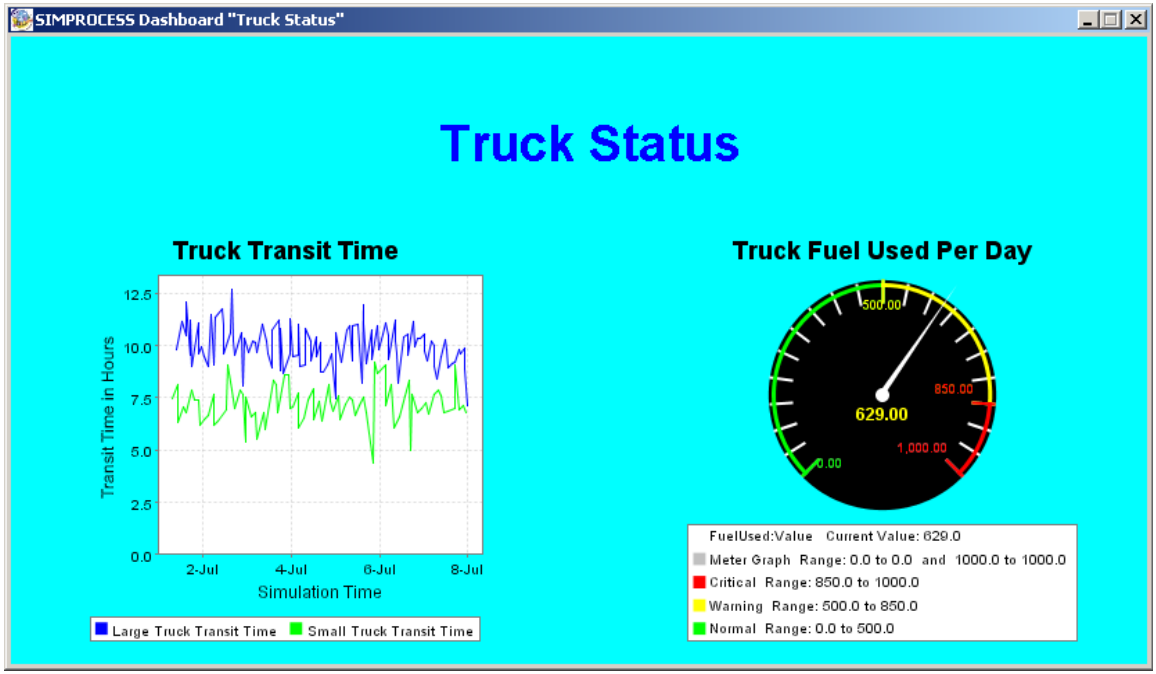
When the simulation is started, the Dashboards assigned to the model will initialize if there are any plot values assigned to any Graphs (for a Text Label, it must also have a **Label** value as noted above). Note that the Dashboard Server window may need to be the active (i.e., frontmost) window for the Dashboard windows to appear if running on the same Windows system as SIMPROCESS. If the Dashboard files referenced by the model are not located in the `dashboards` directory on the server, no Dashboard window will appear, and error messages will be displayed in the Dashboard Server window.



Note that it is possible for messages to not be received by the Dashboard Server, or to be received out of order. To minimize this risk (and improve performance), it is suggested that Dashboards not display a large (more than 10) number of values on a large number of Graphs (more than 4). For example, one Line Graph can plot multiple values (no limit as far as the Line Graph is concerned). However, this means that messages for 10 different values must be received by the Dashboard Server. Alternatively, there could be 10 Meters which each take one value. Again, 10 different values must be received by the Dashboard, and the Dashboard must update 10 different Graphs. If possible, keep the number of values to 10 or less on 4 or less Graphs. Also, it is suggested that the simulation be run with the animation turned on. This slows down the simulation. Simulations that are run with the animation off run extremely fast, so that messages sent to Dashboards could very well arrive faster than the Dashboard Server can handle them (resulting in packet losses). It's usually not necessary to turn on entity movement (although that helps). Turning on Activity Counts normally slows the simulation enough to minimize loss of messages to the Dashboard Server. Running a Dashboard Server across a network can sometimes impose sufficient delay to reduce the chances of message overload as well. This is the recommended way to use Dashboards. These suggestions may or may not be applicable to your environment, depending on a wide range of factors. You should experiment in your own environment as needed.

The image below shows the Truck Status Dashboard during a run. Note that a Dashboard window cannot be closed. Closing the Dashboard Server's main window closes all associated Dashboard

windows and shuts down the server.



Appendices

APPENDIX A

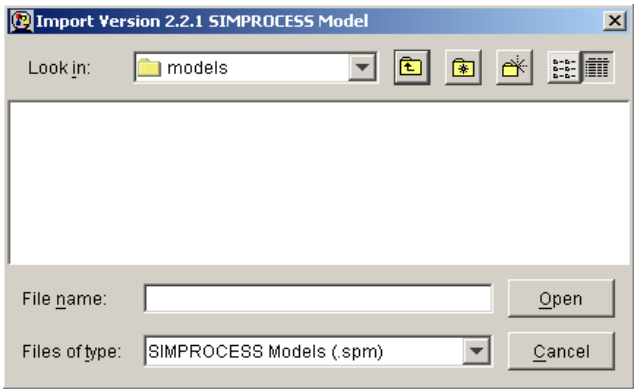
Importing Version 2.2.1 Models

Version 2.2.1 or 2.2.2 models cannot be opened using **File/Open**. Earlier version models must be imported to version 4. This is done using **File/Import/Version 2.2.1 Model...** Model versions earlier than 2.2.1 cannot be imported. These models must be saved in 2.2.1 or 2.2.2 before they can be imported into version 4. However, it is recommended that models be saved in 2.2.3 before importing. SIMPROCESS 2.2.3 is a special Student version (Import Utility) that is designed to prepare models for import to version 4. The 2.2.3 Student version can load and save models from versions of SIMPROCESS earlier than 2.2.1. The special Student version of SIMPROCESS 2.2.3 is available at www.simprocess.com.

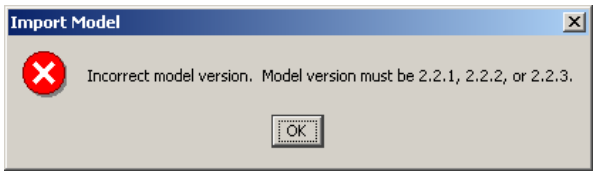
Earlier version models must be imported because the structure of SIMPROCESS and the structure of a SIMPROCESS model file has changed. Version 3 and higher model files are XML files. Thus, they can be read by any XML parser.

Import Procedures

To import a model select **File/Import/Version 2.2.1 Model...** and choose the model to import.



If the file selected is a version 3 or higher file, it will open. However, if the file is pre-2.2.1, an error dialog will appear.



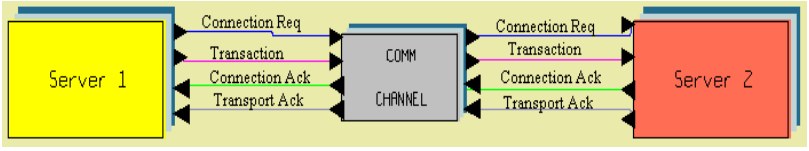
Preparing Your Model For Import

The import procedure reads a 2.2.1, 2.2.2, or 2.2.3 model file and converts the information to XML that can be read by SIMPROCESS version 3 or higher. However, due to limitations in 2.2.1 and 2.2.2 files, some preparation may be required. For larger models, it is recommended that they be opened and saved in 2.2.3. Without being saved in 2.2.3, importing the properties of an Activity, Connector, Pad, etc. from earlier version models depends upon the name of that item. Therefore, if there are duplicate names at the same level, errors will occur, and the conversion will not be complete. Depending on the version of your model, there are three or four primary steps in preparing your model for import. The first item only applies to models that have not been saved in 2.2.3.

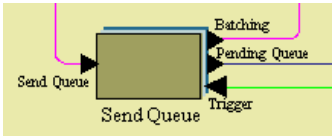
- Make sure there are no duplicate names at the same level (2.2.1 and 2.2.2 only).
- Make sure certain special characters are not in names.
- Make sure all required fields are complete.
- Make sure all special graphics are imported before importing the model.

Duplicate Names (2.2.1 and 2.2.2)

When checking the names, be concerned with names that are at the same level of hierarchy. First, make sure no Activities or Processes have the same name (this should have already been enforced by SIMPROCESS 2.2.*). Second, make sure no Connectors or Pads have the same name as another Connector or Activity/Process. Pads cannot have duplicate names on the same Activity or Process, but they can have duplicate names across Activities/Processes. A Pad cannot have the same name as an Activity or Connector. Finally, make sure everything (Activity, Process, Connector, or Pad) has a name. Version 2.2.2 and earlier will allow you to have Connectors without names. Notice in the example below there are duplicate Connector names. One set of these names will need to be changed for the model to import correctly. A simple solution would be to add a 1 to each Connector name on the right. Note that once the model has been imported the names can be changed back to the original.



The next example shows a Process with a Pad that has the same name. The Process *Send Queue* has a Pad named *Send Queue*. This will cause errors during import.

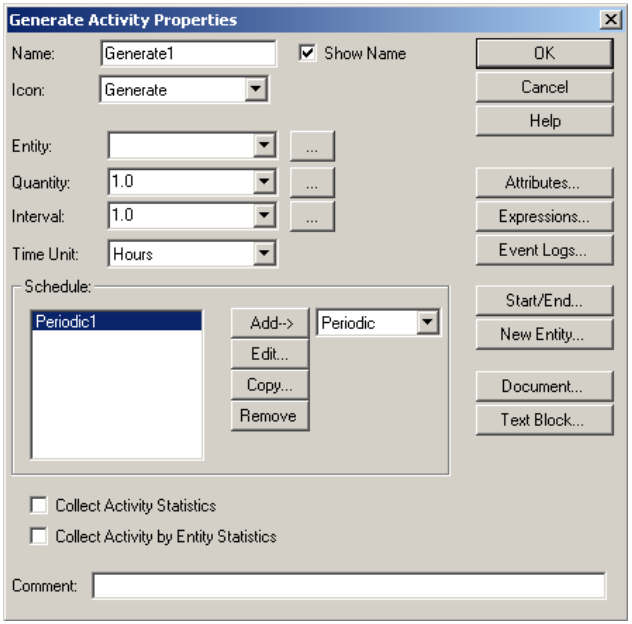


Special Characters

Names of Activities, Processes, Connectors, or Pads cannot have single quotes. These characters will causes errors in the XML parser. For instance, the name *Can't Process* will cause errors. Other characters to avoid are <, >, and /. In general, spaces are not a problem. However, extra spaces will be ignored. Therefore, *Process_1* (one space between *Process* and *1*) is the same as *Process__1* (two or more spaces between *Process* and *1*).

Required Fields

Some Activities have required fields. For instance the Generate Activity needs an entity to generate. Notice the Generate Properties Dialog below. If no entities have been defined in the model, and, thus, the Entity field in the Generate is blank, errors will occur. This same type of error could be caused by Assemble, Batch, and Transform Activities not having an entity type selected. Also, a Branch Activity with no attribute selected when branching by attribute has been set could cause errors during import.



Graphics

If bitmaps were imported for the model, `gif`, `jpeg`, or `png` versions of these bitmaps must be imported before importing the model.

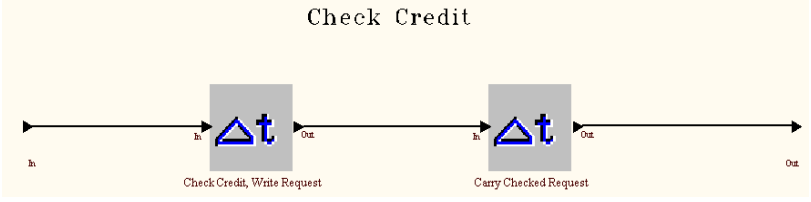
Graphical Import Results

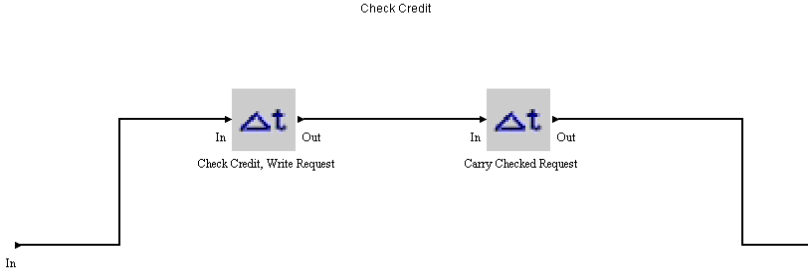
If there are no errors, all properties will import. However, the screens will look different. This is because version 3.0 uses a different coordinate system from earlier SIMPROCESS versions. There are several areas that will be quite noticeably different.

- Activity/Process location
- Activity/Process size
- Connectors not connected to Pads
- Specially drawn Connectors not correct
- Text Blocks, Static labels, and Dynamic labels smaller

Activity/Process Location

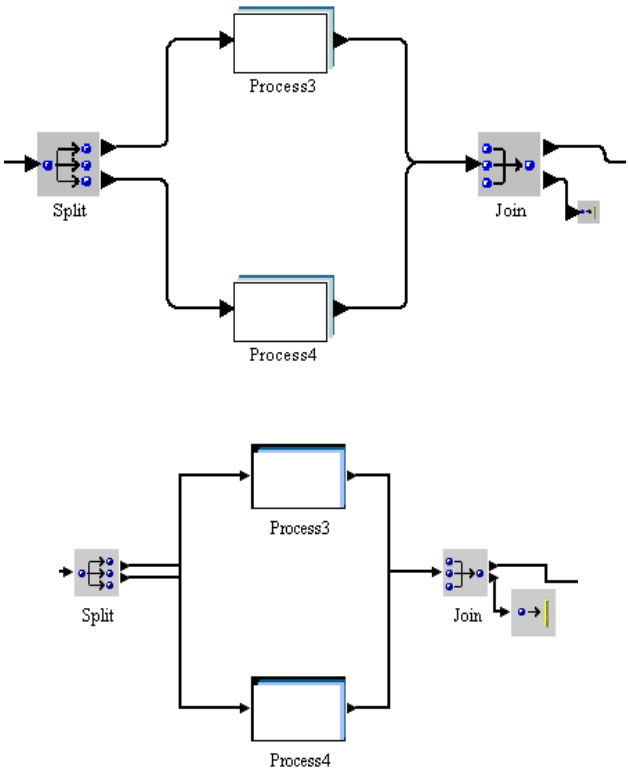
The drawing area for earlier versions of SIMPROCESS was a square. The drawing area for version 3 is a rectangle and is related to your screen size (typically 1024 x 768). Thus, Activities and Processes will be in positions relative to where they were in 2.2.1 or 2.2.2. The change from a square area to a rectangular area will cause some Activities or Processes to be out of place. The two images below demonstrate this. The first is from a 2.2.2 version model. The second is after importing to version 3. Notice that the two delay Activities are higher in relation to the Process Pads in the imported model.





Activity/Process Size

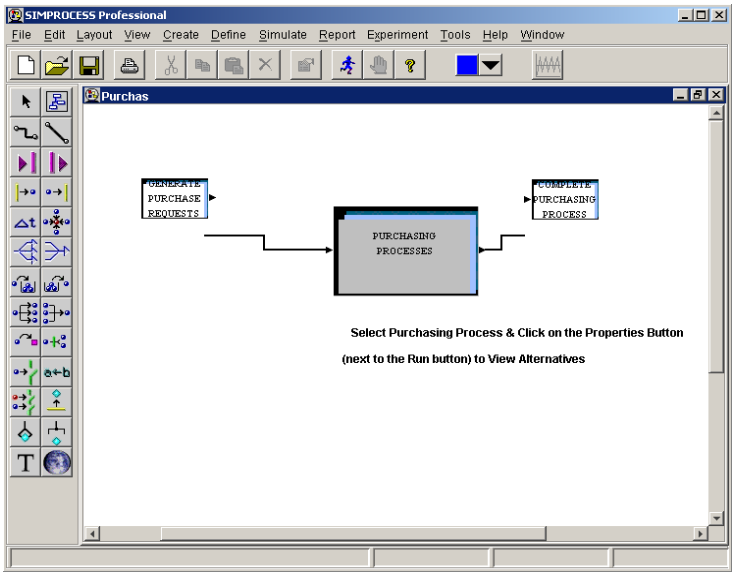
The changes in size are due to changes in the coordinate system and changes in the icons. In version 3, an icon for an Activity or Process cannot be smaller than the graphic for that icon. If the default graphic file is a 32 x 32 image (in pixels), the Activity or Process using that graphic as its icon will not be smaller than 32 x 32. Thus, if your 2.2.* model has Activities or Processes sized very small, they will be larger in 3. Also, even if they were not sized smaller in 2.2.*, they could be larger due to changes in the icons. In the example below, there is a Dispose Activity that has been sized small to catch entities that come out of the NoMatch Pad of the Join Activity. The imported model shows that the Dispose is much larger.

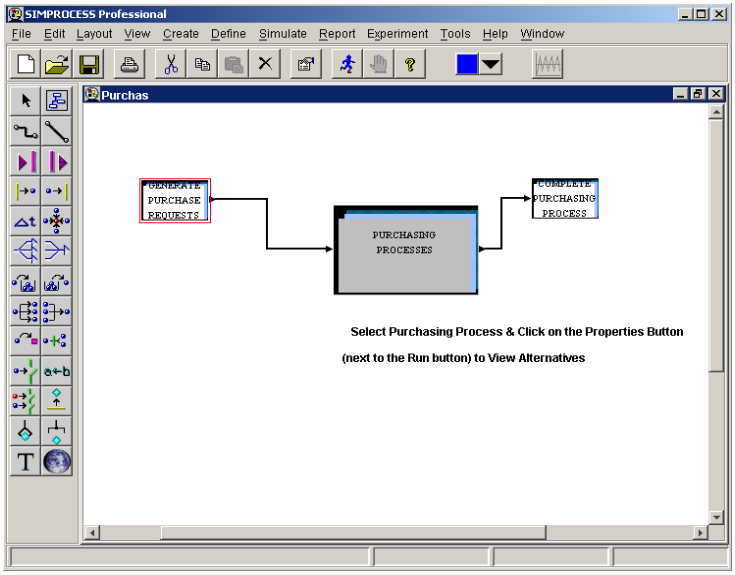


Connectors And Pads

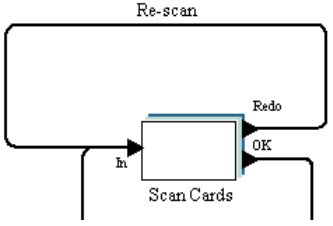
Connectors may not be attached to the Pads. This is due to the changing size of the icons. This is easily fixed by simply slightly moving one of the Activities or Processes. The images below demonstrate

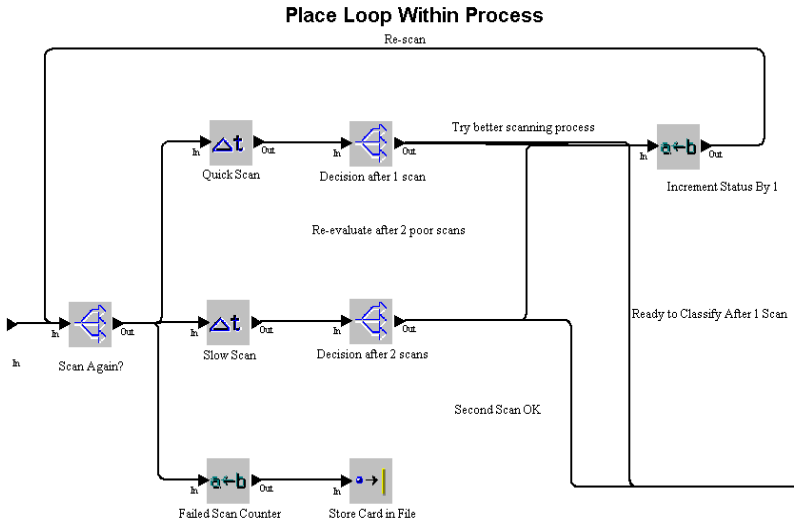
this. The first shows the model as imported. Notice that the Connectors do not connect with the Pads. The second image shows that, after a slight movement of one of the Processes, the Connectors jump into place.


SIMPROCESS Professional
File Edit Layout View Create Define Simulate Report Experiment Tools Help Window
Purchas
GENERATE PURCHASE REQUESTS
PURCHASING PROCESSES
COMPLETE PURCHASING PROCESS
Select Purchasing Process & Click on the Properties Button
(next to the Run button) to View Alternatives

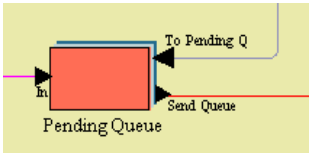

SIMPROCESS Professional
File Edit Layout View Create Define Simulate Report Experiment Tools Help Window
Purchas
GENERATE PURCHASE REQUESTS
PURCHASING PROCESSES
COMPLETE PURCHASING PROCESS
Select Purchasing Process & Click on the Properties Button
(next to the Run button) to View Alternatives

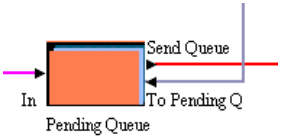
Another issue is a change in Pad rules for version 3. A Connector cannot go from the output Pad of an Activity or Process to an input Pad of the same Activity or Process. This rule is in place to help prevent infinite loops. Thus, if a 2.2.2 model had a Connector from an output Pad of a Process to an input Pad of the same Process, that Connector will not be in the imported model. This is easily fixed by placing another Activity (like a Merge) between the two, or having the loop occur within the Process. In the example below the *Re-scan* Connector in the 2.2.2 model is not allowed in 3.0. The solution is to have the loop within the Process.





Also, Pads may be arranged differently. Pads will be on the correct side of an Activity or Process, but they may be in a different order. Notice that the Pads on the right side of the Process *Pending Queue* are swapped. The first image is from the 2.2.2 model, and the second is from the imported model. Pads on other Activities like the Clone, Split, Assemble, and Gate may be swapped as well.

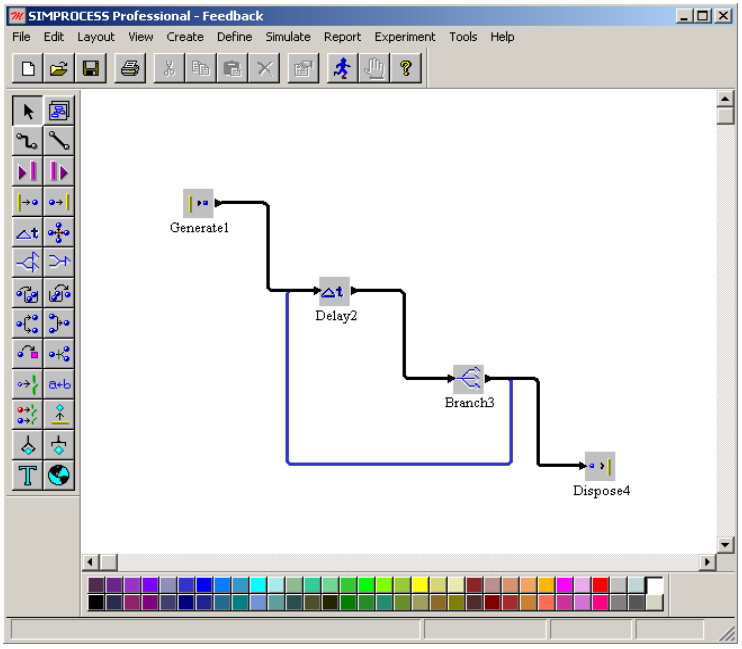




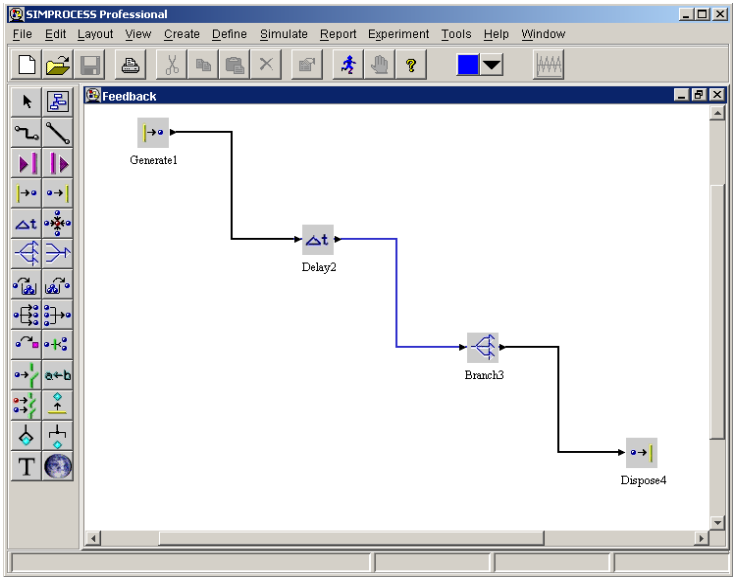
Specially Drawn Connectors

Connectors are drawn by clicking on the output Pad of one Activity and then clicking on the input Pad of another Activity. These Connectors will default to a bent Connector. Special paths for

Connectors are created by clicking on the layout. Every click point creates a right angle. In the 2.2.2 example below, this is how the feedback loop is created (blue Connector).

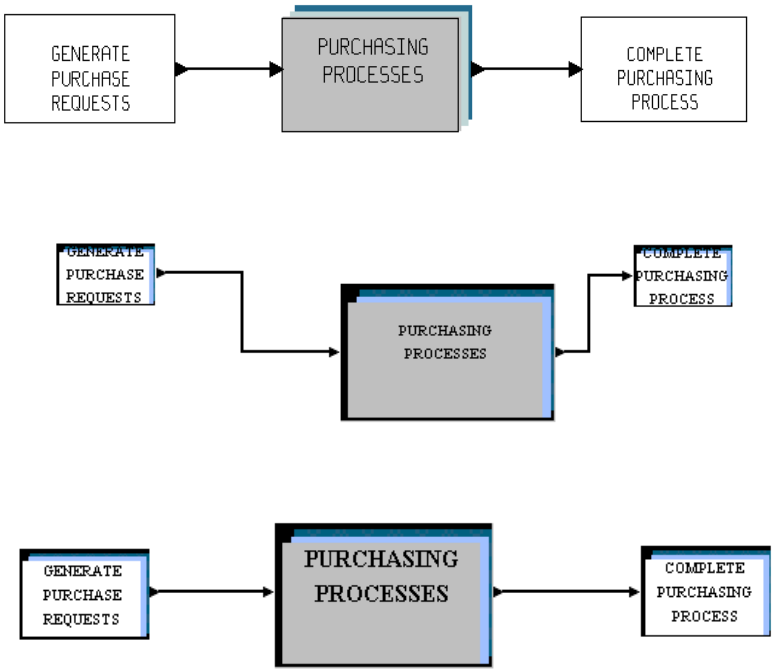


Notice that in the imported model the feedback Connector from Branch3 to Delay2 overlays the Connector from Delay2 to Branch3. This is because the Connector from Branch3 to Delay2 took the default path. Thus, this Connector will need to be deleted and redrawn. Converting Connectors using the vertices of the corners created strange results due to the change in coordinate systems. Using the default Connector between Activities means only special Connectors need to be redrawn.

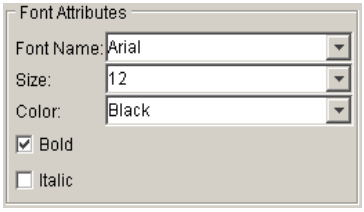


Text Blocks, Static Labels, and Dynamic Labels

Text blocks are labels that can display on Processes or Activities. In earlier versions of SIMPROCESS, the font used for text blocks was a vector font. The font would scale as the Process or Activity was resized. In SIMPROCESS 3, the text blocks were improved to allow the font attributes (font type, color, size, and style) to be set. This requires using the fonts native to your system. Therefore, the font will not scale as a Process or Activity is resized. During conversion, the default font attributes are used. The default font attributes may not fit the Process or Activity, or the default font attributes may be too small for the Process or Activity. The model below is a 2.2.2 model. The image that follows shows the imported model. Notice that for the outer two Processes the text blocks are too large and for the Process in the middle the text block is too small. Also, notice the location difference of the center Process. For the Processes where the text block is too large, either the Process can be sized larger or the text block can be sized smaller. The third image shows the corrections. The two outer Processes were sized larger. The font size was set larger for the text block for the center Process, and the font style was set to bold. Finally, the **Align** option on the **Edit** menu was used to line up the Processes.

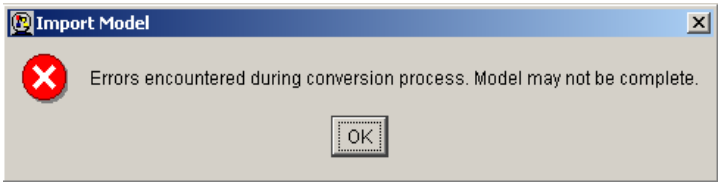


Static and dynamic labels can experience the same results during conversion. Although, labels do not overlay a Process or Activity like a text block, the imported labels may be smaller than desired. Again, this is due to vector fonts being eliminated. To change a label, just open up the properties and change the font attributes.



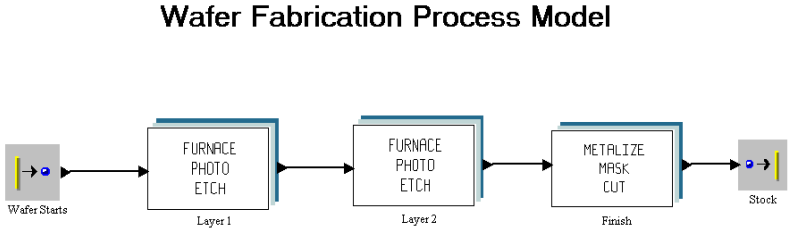
Properties Import Results

If the model has been prepared properly, there should be no errors during the import. If errors do occur, an error dialog will appear.

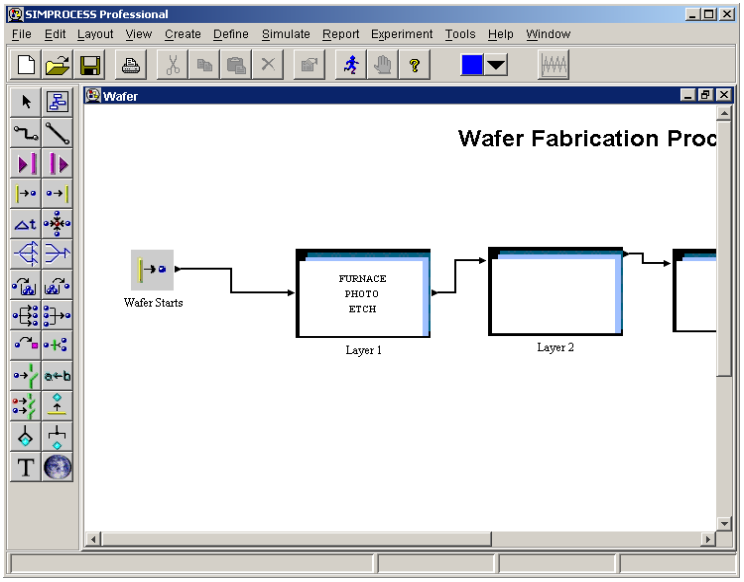


If the error dialog appears, open the `simprocess.log` file in the `\SIMPROCESS\SPSYSTEM` directory. This file will contain more detailed error messages. The first error listed is the one to focus on. Normally, the error messages that follow the first one result from the first error.

The image below shows the top level of the 2.2.2 demo model Wafer.spm. This model will be used as an example for diagnosing errors in properties.

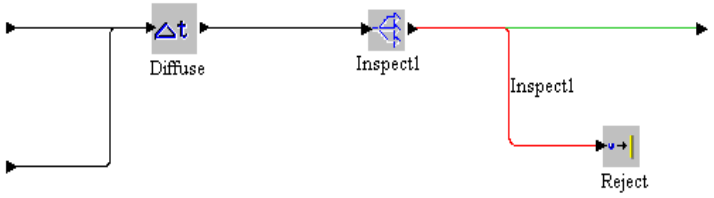


As an example, an import of the 2.2.2 demo model Wafer.spm produced the following error in simprocess.log: **Error in Activity properties of Activity Inspect1 in imported model Wafer**. This error means the problem occurred somewhere close to the Activity named Inspect1. In the image below, notice the graphics of the imported model. The layout shows that the text block is missing from the Process Layer2. Also, the Pads are not in the proper place for Layer2. This indicates that the error occurred in the Process Layer1 since no properties for Layer2 were imported.



To solve this, open the model in SIMPROCESS 2.2.2. or 2.2.1. If you do not know exactly where the Activity named is, you can use the Find Activity feature of the Activity Browser to find it.

Notice that there is a Connector named *Inspect1,* as well as the Activity named *Inspect1*. This is the cause of the problem. Changing the name of the Connector or the Activity is the solution. In this particular model, this same Activity/Connector combination is in Layer2 and needs to be changed there as well. (This error caused by duplicate names will not occur with models saved in 2.2.3.)



Import Troubleshooting

The table below gives sample error messages from the simprocess.log file along with possible causes.

If the error message gives a specific Activity type (such as Assemble, Batch, etc.) there is usually something missing from the properties for that Activity. The errors listed below are the most common. The last four are not specific to a particular Activity type.

If errors persist, contact SIMPROCESS Technical Support at simprocess@caci.com for assistance.

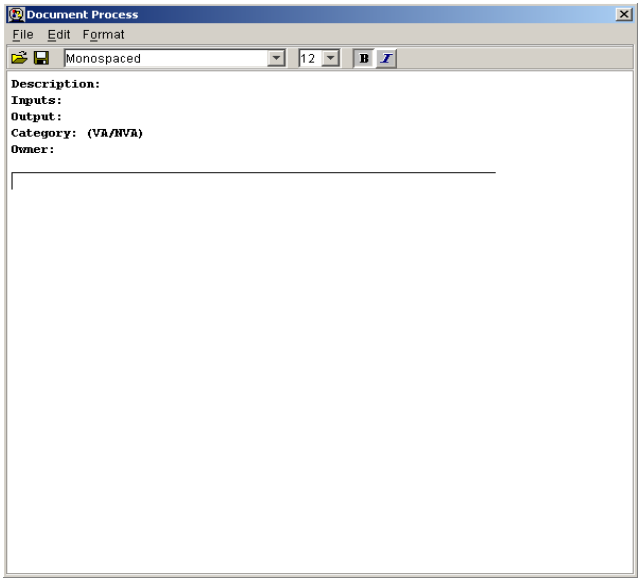
TABLE 1. Import Errors and Causes

Error	Cause
Error in schedules for Generate Generate1 in imported model Feedback	Entity field is blank in a Generate schedule
Error in Activity properties of Activity Inspect1 in imported model Wafer	A Connector or Pad has the same name as the Activity listed (2.2.1 and 2.2.2 only).
Error in Dummy Connector > in imported model Wafer	A Connector is missing a name (2.2.1 and 2.2.2 only).
SPDOM.selectSingleNode exception javax.xml.transform.TransformerException: misquoted literal... expected single quote!	A name has a single quote.
Error in Connector Rejects in imported model Wafer	Two Connectors have the same name (2.2.1 and 2.2.2 only).

Importing Document Files

Versions of SIMPROCESS prior to 3 stored model documentation in files in the model folder. These files will not import automatically. The document feature has been improved in version 3. No longer is the documentation stored in separate files. In 3 it is part of the model file. For the documentation to be part of the model, the text must be RTF. The files in earlier version models are ASCII if NotePad was used to create the text or some other format if another text editor (such as MS Word) was used. To import these files they must first be saved as RTF. This is easily done in MS Word. There is also shareware available on the internet that will convert ASCII files to RTF (`http://www.jafsoft.com/asctortf`). The names of the files converted to RTF are not important to SIMPROCESS. Once the files are RTF, simply click the **Document** button on the item for import. There is a **Document** button on all Activity, Process, entity, and resource properties dialogs. Also, there is **Model Documentation** on the **Define** menu.

Clicking the **Document** button brings up an RTF editor.



From the **File** menu choose **Read from File...** This allows you to read in the RTF document files which makes the file a part of your model file.

This must be done for every documentation file that was created for your 2.2.* model. All of these files will be located in the model's folder and will have the extension `.doc`.

APPENDIX B

Activity Summary Table

		Required Parameters	Non-standard Options
Assemble	Receives 2 or more entities and assembles them into a single entity for release.	Component Entity Assembled Entity	Resources Delay Batch Components
Assign	Assigns values to entity attributes.	Entity Attributes	Resources Delay Set Entity Priority
Batch	Stores entities until a condition is met, then releases them as one, while retaining their individual identity.	Quantity to Batch Min Batch Size Max Hold Time Batch Entity Type	Resources Delay
Branch	Routes entities to different paths in the model network.	Branch Type	Resources Delay

		Required Parameters	Non-standard Options
Clone	Clones entities.	Number of Entities	Resources Delay
Delay	General-purpose activity.	Delay Time	Resources
Dispose	Disposes of entities.		Maximum entity Count
Free Resource	Releases resources obtained by Get Resource activities.	Release actions	Release all allocated resources
Gate	Accumulates entities until a condition is met, then releases a specified number of them.	Threshold Release ON/OFF Threshold Release Quantity (if Threshold Release ON) Trigger Release Quantity (if Trigger Release ON)	Resources Delay Batch released entities
Generate	Generates entities.	Entity type Quantity Interval	Start and End dates) Schedule Type Schedule Items
Get Resource	Obtains resources to be held during several activities.	Resources Tag attached to allocation	
Join	Reunites entities divided at a Split activity.	Family Name	Batch family members Resources Delay
Merge	Merges entities and routes them in a single stream.		
Replenish Resource	Adds units to consumable resources.	Replenish actions (Resource and Units)	
Split	Divides one entity into several to model the division of processing among several activities.	Family name	Copy Priority Resources Delay
Synchronize	Coordinates the release of various entities.	Number of Pads	Resources Delay

		Required Parameters	Non-standard Options
Transfer	Transfers entities from one portion of a model to another without a connector, or transfers an entity to another SIMPROCESS model.	Send or Receive Local or Remote Connection or Protocol	Most standard options are not available
Transform	Transforms arriving entities from one type to another, and releases one or more of the new type.	Number of Output Entities Output Entity type	Copy Attributes Resource Delay
Unbatch	Separates a batched entity into its constituent parts.		Resource Delay Retain Batched Entity Unbatch Nested Batches

APPENDIX C

SIMPROCESS File Structure

The SIMPROCESS installation program creates a directory (called `SIMPROCESS` unless you chose a different name during installation). In this directory there are a number of important files and seven subdirectories. The primary subdirectories are the System Directory, named `SPSYSTEM`, the User Working Directory, named `SPUser`, and the `models` directory. This appendix briefly describes the structures and contents of these directories and subdirectories. Here is the basic directory structure:

```
SIMPROCESS installation directory
   SPSYSTEM
         xfit (Windows)
   SPUser
         document
         plots
         SampleFiles
   models
         Demos
   UninstallerData
   jre
   ext
   dashboardserver
```

Installation Directory

```
GetTimeZone.class ( READ ONLY; Java class file required by SIMPROCESS )
java2rei.dll      ( READ ONLY; Rose Automation Capability Java interface
library - Windows only )
libOptQuest.so    ( READ ONLY; OptQuest for SIMPROCESS library - Linux )
OptQuest.dll      ( READ ONLY; OptQuest for SIMPROCESS library - Windows )
```

SPSYSTEM Directory

```
InstallSettings.win.xml ( READ ONLY; defaults for some installation set-
tings - Windows only )
InstallSettings.lnx.xml ( READ ONLY; defaults for some installation set-
tings - Linux only )
jh.jar              ( READ ONLY; SIMPROCESS executable jar file )
plot.jar            ( READ ONLY; SIMPROCESS executable jar file )
simprocess.jar      ( READ ONLY; SIMPROCESS executable jar file )
SPHelp.jar          ( READ ONLY; SIMPROCESS executable jar file )
SPRemote.jar        ( READ ONLY; SIMPROCESS executable jar file )
xalan.jar           ( READ ONLY; SIMPROCESS executable jar file )
xercesImpl.jar      ( READ ONLY; SIMPROCESS executable jar file )
xmlParserAPIs.jar   ( READ ONLY; SIMPROCESS executable jar file )
opt.jar             ( READ ONLY; SIMPROCESS executable jar file )
jakarta-poi.jar     ( READ ONLY; SIMPROCESS executable jar file )
java2rei.jar        ( READ ONLY; SIMPROCESS executable jar file - Windows
only)
jcommon.jar         ( READ ONLY; SIMPROCESS executable jar file )
jfreechart.jar      ( READ ONLY; SIMPROCESS executable jar file )
simprocess.err      ( READ ONLY; SIMPROCESS application error messages;
created and/or emptied when SIMPROCESS is run )
simprocess.log      ( READ ONLY; SIMPROCESS application messages; created
and/or emptied when SIMPROCESS is run )
timezone.dat        ( READ ONLY; SIMPROCESS initialization data file )
timezone.err        ( READ ONLY; SIMPROCESS initialization error file )
optQuest.log        ( READ ONLY; OptQuest for SIMPROCESS application mes-
sages )
optQuest.err        ( READ ONLY; OptQuest for SIMPROCESS application error
messages )
GetStart.pdf        ( READ ONLY; on-line documentation file )
SPUser.pdf          ( READ ONLY; on-line documentation file )
ExpertFitGuide.pdf  ( READ ONLY; on-line documentation file )
RoseExists.dll      ( READ ONLY; SIMPROCESS Rose library - Windows only )
license.dll         ( READ ONLY; SIMPROCESS license library - Windows only)
libLinux.so         ( READ ONLY; SIMPROCESS license library - Linux only )
license.dat         ( READ ONLY; license file obtained from CACI )
```

xfit Subdirectory

This directory contains the files necessary to run the ExpertFit application, included on Windows systems only.

SPUser Directory

```
sProcDB.properties  (database connection properties - required to use a
SIMPROCESS database)
mysql.sProcDB.properties  (sample database connection properties for use
with a MySQL database; may serve as a template for other database tools)
SimProcDB.mdb       (MS Access database - Windows only)
simprocessdb.sql    (sample DDL statements to create a "simprocess" data-
base in MySQL for storing Experiment results; may serve as a template for
other database tools)
UserPreferences.xml (created on first run, user preferences stored here)
UserFiles.jar       (created when importing graphics and icons, or when
saving Libraries)
Experiments.xml     (created when experiments are defined or imported)
```

document Subdirectory

This directory is used to customize headings for Activity, Entity, Connector, Resource, and model documentation (**Document** button on properties dialogs). The directory is empty initially. The headings are customized with the use of text files that have the extension `.txt`. Each line of a file is considered a heading. For instance, the lines

```
Activity Name:
Resources Used:
```

in a file would be considered two separate headings. The contents of the `.txt` files completely replace the default headings.

Listed below are the names that can be used for the `.txt` files.

- `Activity.txt` - changes the headings for all Activities
- `process.txt` - changes the headings for processes
- `Entity.txt` - changes the headings for Entity types
- `Resource.txt` - changes the headings for Resources
- `Connector.txt` - changes the headings for Connectors
- `model.txt` - changes the headings for the **Model Description...** (**Define** menu).

The file `Activity.txt` changes the headings for all Activities. To change the documentation headings for a specific Activity, name the file the same name as the type of the Activity along with the `.txt` extension. Some examples are `delay.txt`, `replenishResource.txt`, `assemble.txt`, and `getResource.txt`. Notice that the type of the Activity must be spelled out completely with no spaces in the file name.

Not all files are required. If only the document headings for Entity types need to be changed, then `Entity.txt` is the only file that needs to exist.

plots Subdirectory

This directory initially does not exist. It is created when real-time plots are auto-saved.

SampleFiles Subdirectory

This directory contains the source code for the files in the `com.caci.demo` package in `SPRemote.jar`. Also, sample batch files and scripts that start the Java RMI Registry, SPServer, and SPPlotServer are included, which can be copied and used as templates if desired.

models Directory

SIMPROCESS defaults to this directory as its starting point when saving or opening models.

Demos Subdirectory

This directory contains demonstration and reference models.

```
As-Is.spm           ( Getting Started model )
Assemble.spm        ( Assemble demo model)
Airport.spm         ( demonstration model)
Batch.spm           ( Batch/Unbatch demo model )
CallCenter.spm      ( demonstration model )
Call Status.spd     ( demonstration dashboard )
Cashier.spm         ( demonstration model )
CnfgMgmt.spm        ( demonstration model )
Credit.spm          ( demonstration model )
Customer Service.spm( demonstration model )
Emergency Room.spm  ( demonstration model)
Remote Plot.spm     ( demonstration model )
HelpDesk.spm        ( demonstration model )
Human Resources.spm ( demonstration model )
H2O.spm             ( Get Resource demo model)
Inventory.spm       ( demonstration model )
Justice System.spm  ( demonstration model )
```

```
Network.spm          ( demonstration model )
NewAccount.spm       ( demonstration model )
Preempt.spm          ( demonstration model )
Purchasing.spm       ( demonstration model )
Remote.spm           ( External schedule model )
RemoteCall.spm       ( RemoteCall demo model )
Sample Downtime.spm  ( Resource downtime model )
SplitJoin.spm        ( Split/Join demo model )
Supply.spm           ( Supply chain demo model )
To-Be.spm            ( Getting Started model )
```

UninstallerData Directory

The installation program will create this folder with all resources needed to fully uninstall SIMPROCESS. This folder should remain unchanged to ensure that a proper uninstall is possible.

jre Directory

This directory contains the Java Runtime Environment referenced by the SIMPROCESS program.

ext Directory

When calling an external Java program from an Expression via the RemoteCall statement or external Java classes via the ExternalCall statement, it may be necessary to add compiled Java class files to the classpath used by SIMPROCESS. Typically, SIMPROCESS must be able to find a class file for the Interface defining the available method(s) in your Java class if it's to be used via RMI and the RemoteCall statement, and it must be able to locate the "Stub" class file to act as a local representation of the actual Java object which implements the method(s) to be called. In order to make sure that SIMPROCESS can resolve those classes when attempting to execute your RemoteCall or ExternalCall statement, copy the class files into this location. If your classes do not contain a "package" statement, you can place them directly into `ext`. If organized as a package, simply create the needed directory structure for the package inside `ext`. Then start (or restart) SIMPROCESS, and it will include these classes in its classpath. Note that SIMPROCESS will not recognize jar files placed in this directory. Jar files must be placed in the `jre/lib/ext` directory.

dashboardserver Directory

This directory contains the files required to run a Dashboard Server. (See "Displaying Dashboards" on page 395.)

APPENDIX D

Statistical Distributions

The following pages give a brief description of the standard statistical distributions available in SIMPROCESS, as well as their required parameters.

Most of the parameters for continuous distributions can be classified, on the basis of their physical or geometric interpretation, as being one of three basic types: location, scale, or shape parameters. The following discussion is taken from the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000).

A location parameter l specifies an abscissa (x axis) location point of a distribution's range of values; usually, l is the midpoint (e.g., the mean of a normal distribution) or lower endpoint (e.g., location for a Pearson type V distribution) of the distribution's range. As l changes, the associated distribution merely shifts left or right without otherwise changing. Also, if the distribution of the random variable X has a location parameter of 0, then the distribution of the random variable $Y = X + l$ has a location parameter of l.

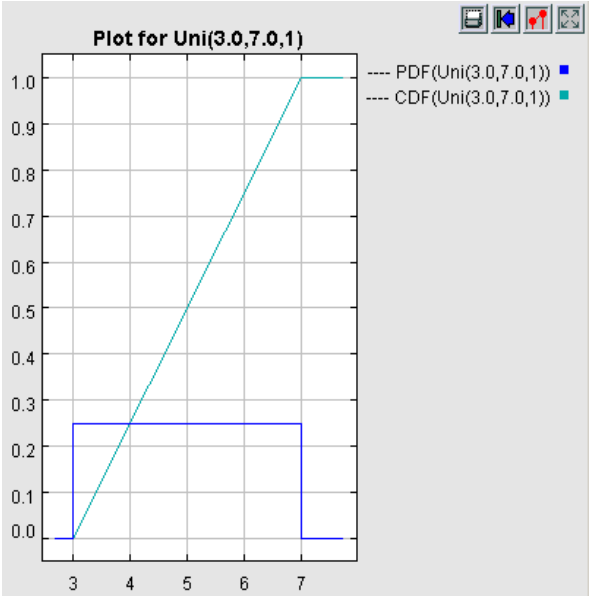
A scale parameter b determines the scale (or unit) of measurement of the values in the range of the distribution. (The standard deviation is a scale parameter for the normal distribution.) A change in b compresses or expands the associated distribution without altering its basic form. Also, if the random variable X has a scale parameter of 1, the distribution of the random variable $Y = bX$ has a scale parameter of b.

A shape parameter a determines, distinct from location and scale, the basic form or shape of a distribution with the general family of distributions of interest. A change in a generally alters a distribution's properties (e.g., skewness) more fundamentally than a change in location or scale. Some

distributions (e.g., exponential and normal) do not have a shape parameter, while others (e.g., beta and Pearson type VI) may have two.

The last parameter of each distribution is the stream number.This is the random-number stream that will be used to general random values from the distribution. Possible values for stream are 1, 2, …, 215, with 1 being the default.

Uniform Distribution

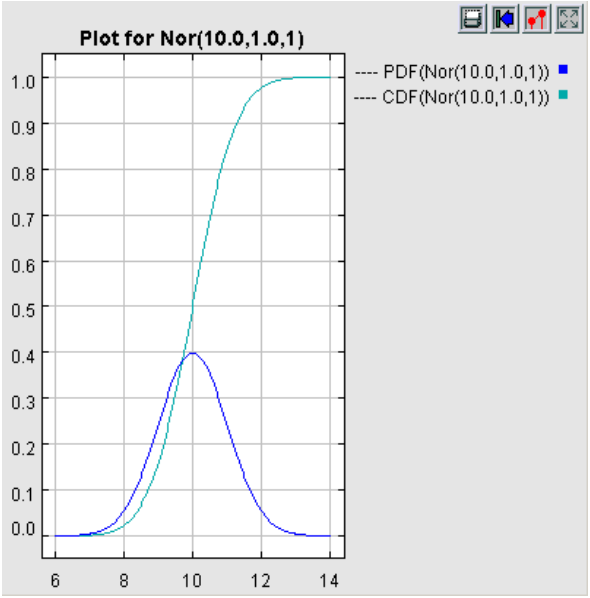


Probability density function and cumulative density function for a uniform distribution with minimum = 3 and maximum = 7.

Syntax: Uni(minimum, maximum, stream)

The uniform distribution (continuous) is equally likely to take on any real number in the finite interval [**minimum**, **maximum**]. The real numbers produced by a random-number generator (appear to) have a uniform distribution on the interval [0, 1].

Normal Distribution



Probability density function and cumulative density function for normal distribution function with mean = 10, standard deviation = 1. There are two normal distributions in SIMPROCESS. One only returns non-negative values (zero or higher), and the other will return negative values.

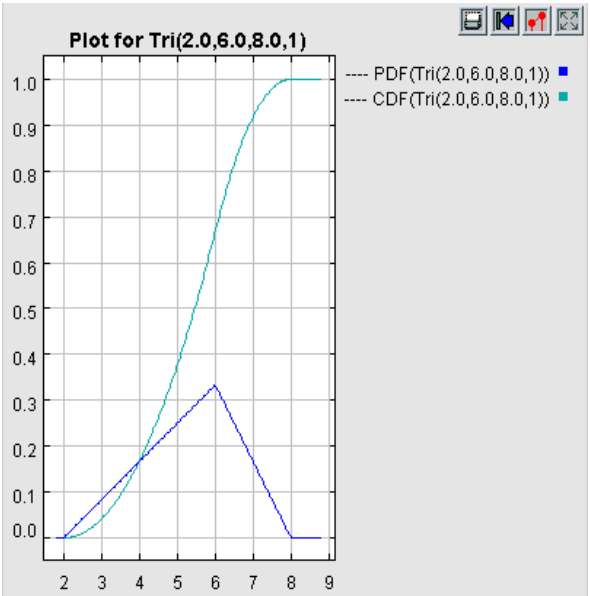
Syntax: Nor(mean, standard deviation, stream) - returns only non-negative values

This distribution is similar to the classical normal distribution, but if a negative value is generated, it is rejected and new values are generated until a non-negative value is generated. In general, this distribution will not be a good model for the time required to perform some task, since task-time distributions are almost always *skewed to the right*.

Syntax: Nrm(mean, standard deviation, stream) - unbounded

This is the classical normal distribution, which is found in most statistics books. It takes on real values between minus infinity and plus infinity. The density function is the familiar "bell-shaped" curve, which is symmetric about the **mean**. The probability that a value is between the **mean** minus 2 **standard deviations** and the **mean** plus two **standard deviations** is approximately 0.95. This distribution should not be used to model the time required to perform some task, since the normal distribution can take on negative values. Furthermore, as stated above, the distribution of the time to perform some task is almost always *skewed to the right*, rather than being symmetric.

Triangular Distribution

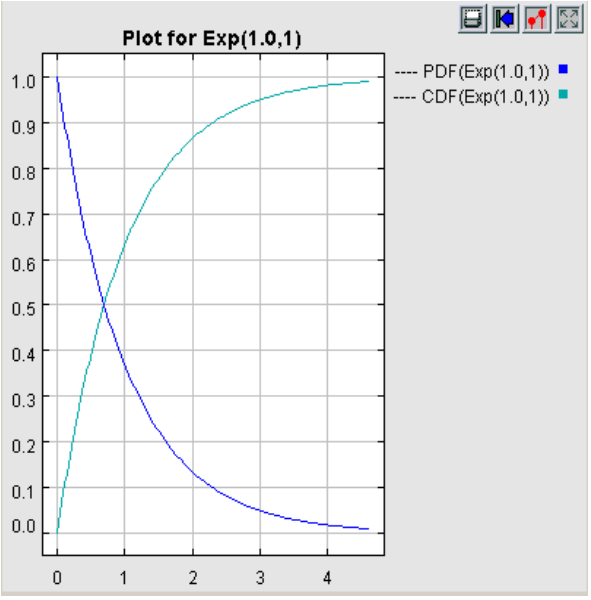


Probability density function and cumulative density function for a triangular distribution with minimum = 2, mode = 6, and maximum = 8.

Syntax: Tri(minimum, mode, maximum, stream)

The triangular distribution (continuous) is typically used as a rough model for the time required to perform some task when no real-world data are available. A triangular distribution takes on values in the finite interval [**minimum**, **maximum**], with values near the **mode** being most likely to occur. Subjective estimates of the three parameters are obtained from subject-matter experts. The mean of a triangular distribution is only equal to the **mode** when the distribution is symmetric.

Exponential Distribution

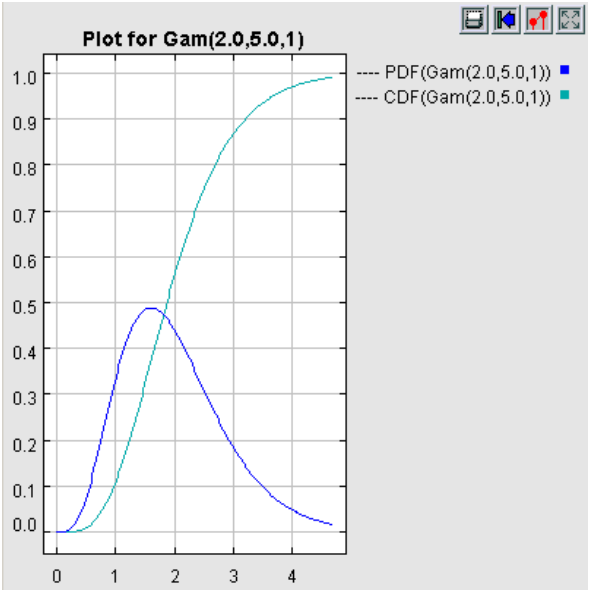


Probability density function and cumulative density function for an exponential distribution with mean = 1.

Syntax: Exp(mean, stream)

The exponential distribution (continuous) is commonly used to model interarrival times of customers to some system when the arrival rate is approximately constant over the time period of interest. It is also sometimes used to model the time to failure of a piece of equipment. The mean of an exponential distribution is a scale parameter. An exponential distribution with **mean** = *m* is a gamma distribution with **mean** = *m* and **shape** = 1. An exponential distribution with **mean** = *m* is a Weibull distribution with **shape** = 1 and **scale** = *m*. If interarrival times of customers have an exponential distribution with **mean** = *m*, then the number of arrivals in any time interval of length t has a Poisson distribution (discrete) with **mean** = *t/m*.

Gamma Distribution

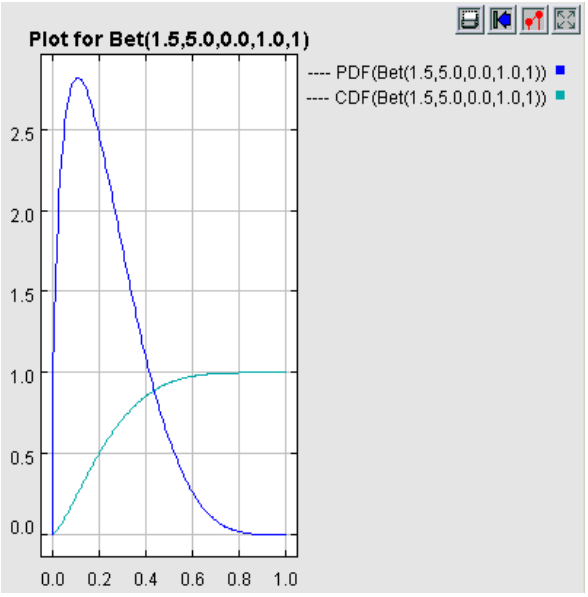


Probability density curve and cumulative density function for a gamma distribution with mean = 2 and shape = 5.

Syntax: Gam(mean, shape, stream)

The gamma distribution (continuous) could be used to model the time required to perform some task. If a gamma distribution has parameters **mean** = *m* and **shape** = *a*, then *b* = *m/a* is a scale parameter. A gamma distribution with **mean** = *m* and **shape** = 1 is an exponential distribution with **mean** = *m*. When **shape** is a positive integer, the gamma distribution is an Erlang distribution.

Beta Distribution

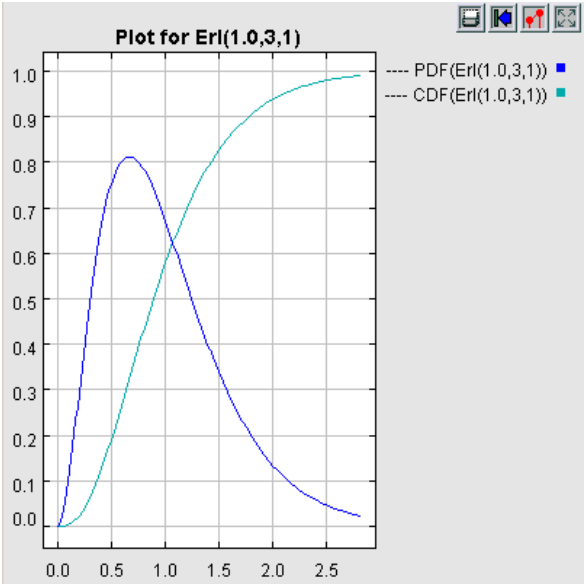


Probability density function and cumulative density function for a beta distribution with shape1 = 1.5, shape2 = 5.0, minimum = 0.0, and maximum = 1.0.

Syntax: Bet(shape1, shape2, minimum, maximum, stream)

The beta distribution (continuous) could be used to model the time required to perform some task when the possible values are restricted to the finite interval [**minimum**, **maximum**]. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > **shape2**, **shape1** = **shape2**, or **shape1** < **shape2**, respectively. A beta distribution with **shape1** = **shape2** = 1 is a uniform distribution with the interval [0, 1].

Erlang Distribution

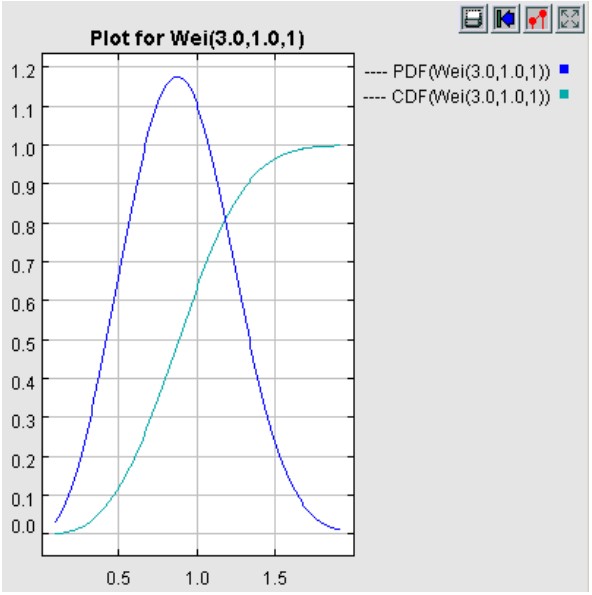


Probability density function and cumulative density function for an Erlang distribution with mean = 1 and shape = 3.

Syntax: Erl(mean, shape, stream)

The Erlang distribution (continuous) could be used to model the time required to perform some task. If an Erlang distribution has parameters **mean** = *m* and **shape** = *a*, then *b* = *m/a* is a scale parameter. An Erlang distribution is just a gamma distribution whose shape parameter is a positive integer. The sum of *k* exponential random variables with **mean** = *m* is an Erlang distribution with **mean** = *km* and **shape** = *k*.

Weibull Distribution

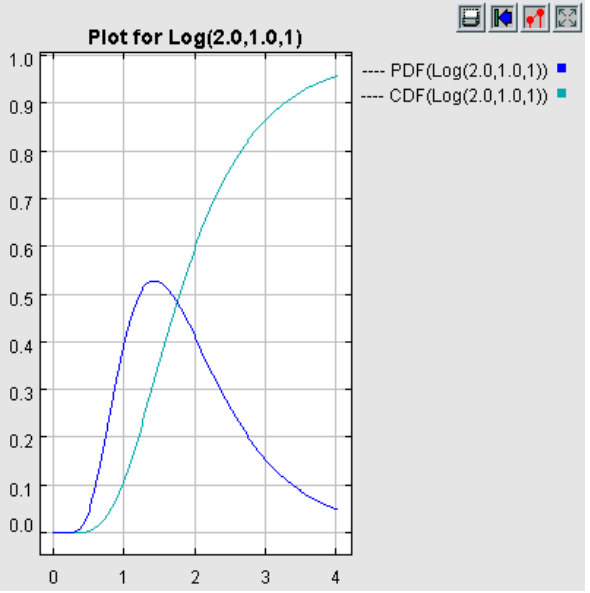


Probability density function and cumulative density function for a Weibull distribution with shape = 3 and scale = 1.

Syntax: Wei(shape, scale, stream)

The Weibull distribution (continuous) could be used to model the time required to perform some task. It is also sometimes used to model the time to failure of a piece of equipment. A Weibull distribution with parameters **shape** = 1 and **scale** = *b* is an exponential distribution with **mean** = *b*. The Weibull distribution is skewed to the left when **shape** > 3.6.

Lognormal Distribution

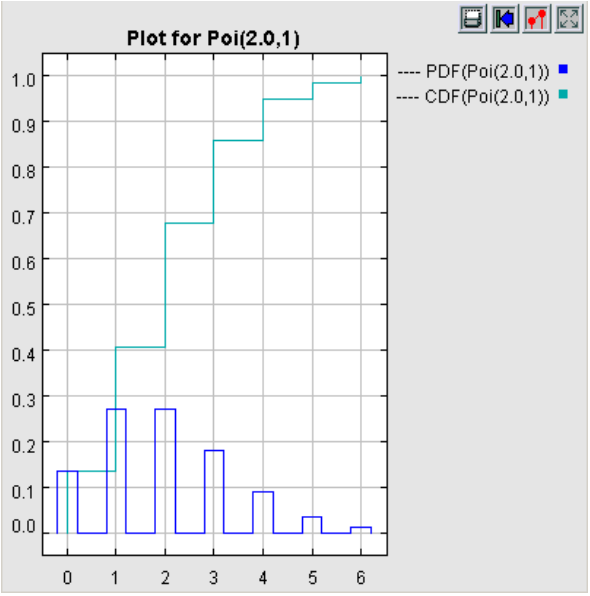


Probability density function and cumulative density function for a lognormal distribution with mean = 2 and standard deviation = 1.

Syntax: Log(mean, standard deviation, stream)

The lognormal distribution could be used to model the time required to perform some task when "large" values sometimes occur. It is always skewed to the right and it has a longer right tail than the gamma or Weibull distributions. The lognormal distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details. Furthermore, the parameters of the lognormal distribution, namely, **mean** and **standard deviation**, correspond to the lognormal distribution and are *not* the mean and standard deviation of the corresponding normal distribution.

Poisson Distribution

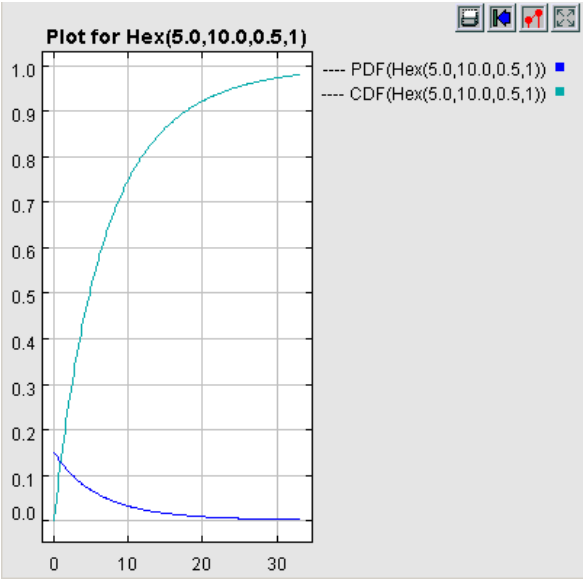


Poisson distribution with mean = 2.

Syntax: Poi(mean, stream)

The Poisson distribution (discrete) with **mean** = *m* is the distribution of the number of customers that arrive to some system in any time interval of length 1 when the interarrival times have an exponential distribution (continuous) with **mean** = 1/*m*.

Hyper Exponential Distribution

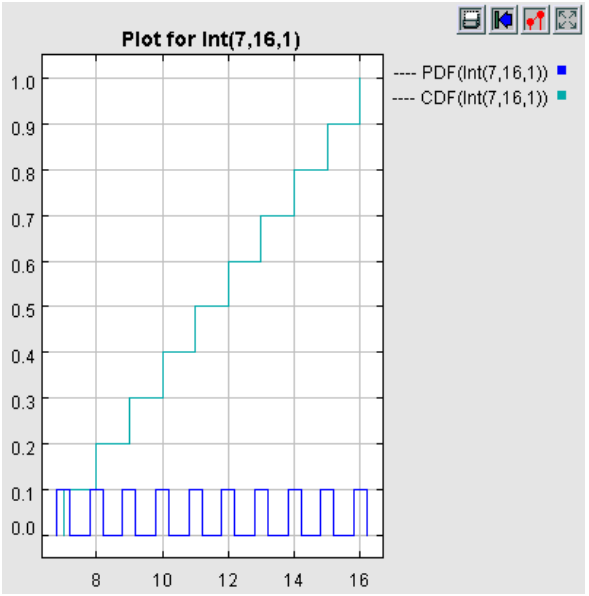


Hyper exponential distribution with mean1 = 5, mean2 = 10, and probability1 = 0.5.

Syntax: Hex(mean1, mean2, probability1, stream)

The hyper exponential distribution (continuous) is a mixture of two exponential distributions. Specifically, a hyper exponential distribution with parameters **mean1**, **mean2**, and **probability1** takes on values from an exponential distribution with parameter **mean1** with a probability of **probability1** and takes on values from an exponential distribution with parameter **mean2** with a probability of 1 - **probability1**. A hyper exponential distribution with **probability1** = 1 is an exponential distribution with parameter **mean1**.

Uniform Integer Distribution

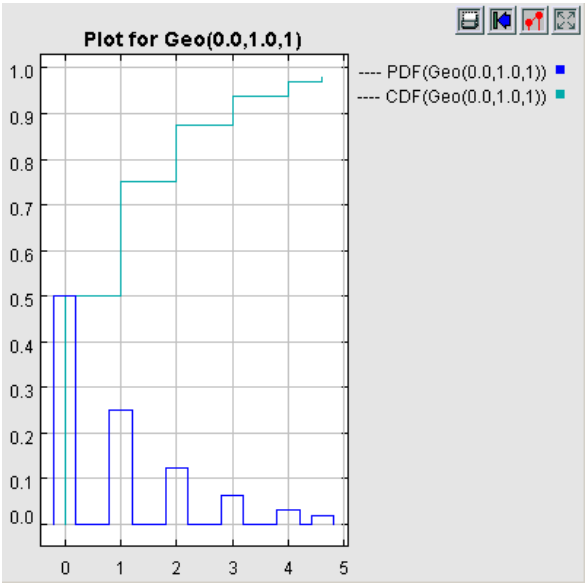


Probability density function and cumulative density function for uniform integer distribution with minimum = 7 and maximum = 16.

Syntax: Int(minimum, maximum, stream)

An uniform integer distribution (discrete) is equally likely to take on any integer in the finite interval [**minimum**, **maximum**], where **minimum** and **maximum** are integers with **minimum** < **maximum**.

Geometric Distribution

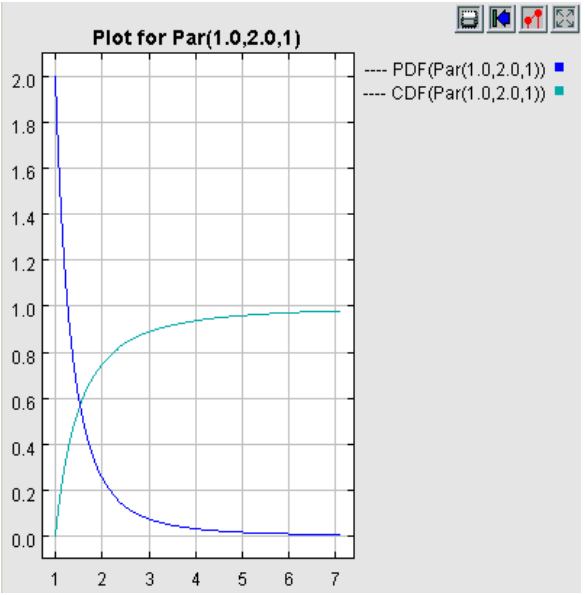


Probability density function and cumulative density function for a geometric distribution with probability = 0.5.

Syntax: Geo(probability, stream)

The geometric distribution (discrete) with **probability** = *p* can be thought of as the distribution of the number of failures before the first success in a sequence of independent Bernoulli trials, where success occurs on each trial with a probability of *p* and failure occurs on each trial with a probability of 1 - *p*.

Pareto Distribution

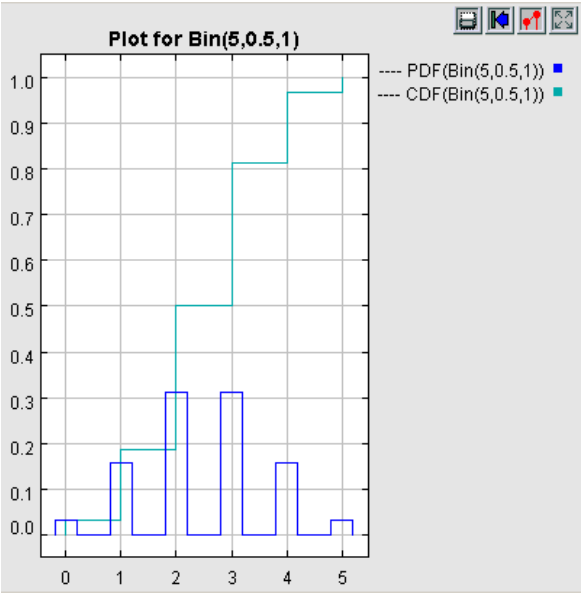


Probability density function and cumulative density function for a Pareto distribution with location = 1 and shape = 2.

Syntax: Par(location, shape, stream)

The Pareto distribution (continuous) could be used to the model interarrival times of customers (e.g., messages) when the traffic is bursty. The mean and variance are finite only if **shape** > 2.

Binomial Distribution

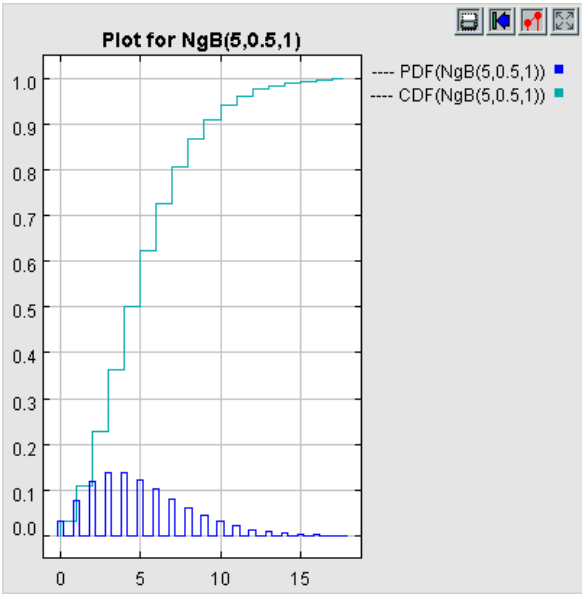


Probability density function and cumulative density function for a binomial distribution with trials = 5 and probability = 0.5.

Syntax: Bin(trials, probability, stream)

The binomial distribution (discrete) with parameters **trials** = t (a positive integer) and **probability** = p can be thought of as the distribution of the number of successes in t independent Bernoulli trials, where success occurs on each trial with a probability of p and failure occurs on each trial with a probability of 1 - p. A binomial distribution with **trials** = 1 is called a Bernoulli distribution with **probability** = p.

Negative Binomial Distribution

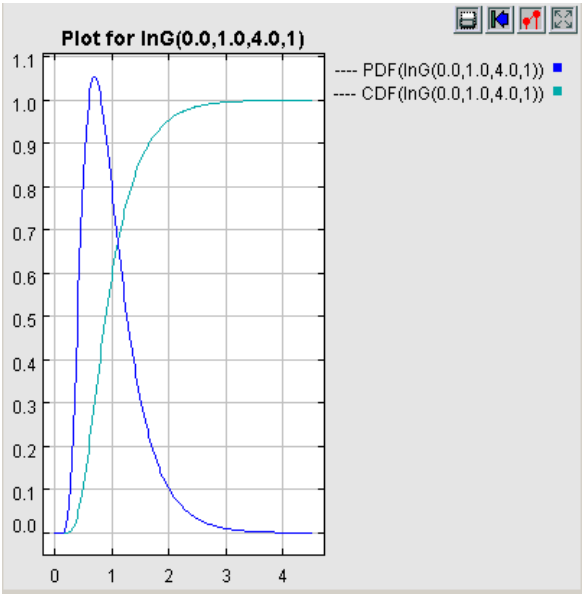


Probability density function and cumulative density function for a negative binomial distribution with s = 5 and probability = 0.5.

Syntax: NgB(s, probability, stream)

The negative binomial distribution (discrete) with parameters **s** and **probability** = *p* can be thought of as the distribution of the number of failures before the **s**th success in a sequence of independent Bernoulli trials, where success occurs on each trial with a probability of *p* and failure occurs on each trial with a probability of 1 - *p*. A negative binomial distribution with parameters **s** = 1 and **probability** = *p* is a geometric distribution with **probability** = *p*.

Inverse Gaussian Distribution

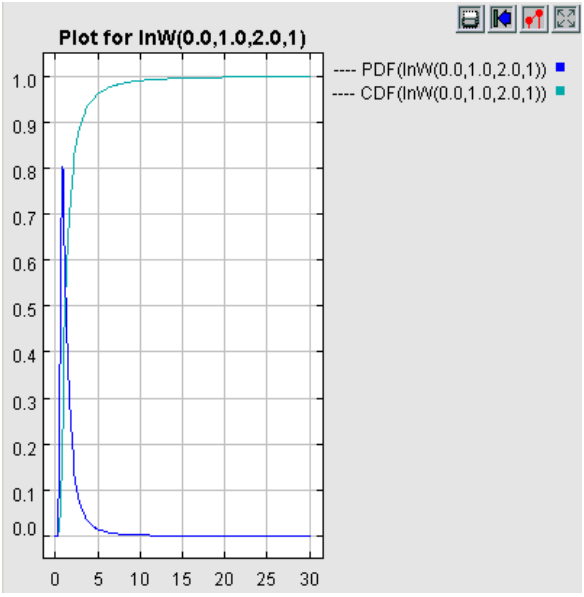


Probability density function and cumulative density function for an inverse Gaussian distribution with location = 0, scale = 1, and shape = 4.

Syntax: InG(location, scale, shape, stream)

The inverse Gaussian distribution (continuous) could be used to model the time required to perform some task.

Inverted Weibull

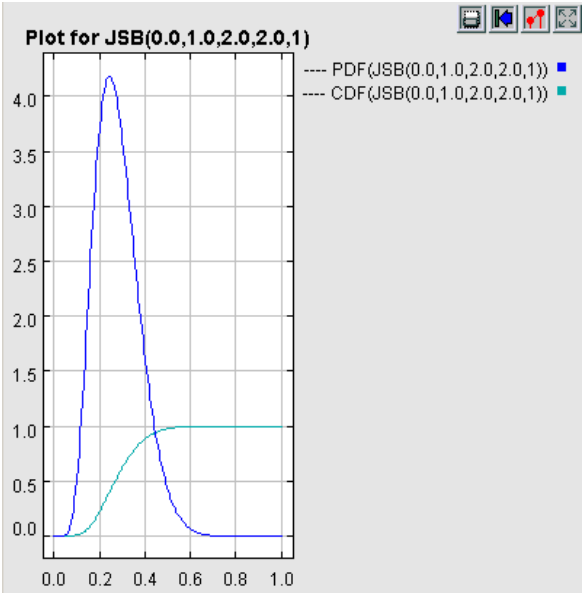


Probability density function and cumulative density function for an inverted Weibull distribution with location = 0, scale = 1, and shape = 2.

Syntax: InW(location, scale, shape, stream)

The inverted Weibull distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. If the random variable X has an inverted Weibull distribution with location = 0, scale = b, and shape = a, then Y = 1/X has a Weibull distribution with scale = 1/b and shape = a. (The location parameter is 0.)

Johnson S_B Distribution

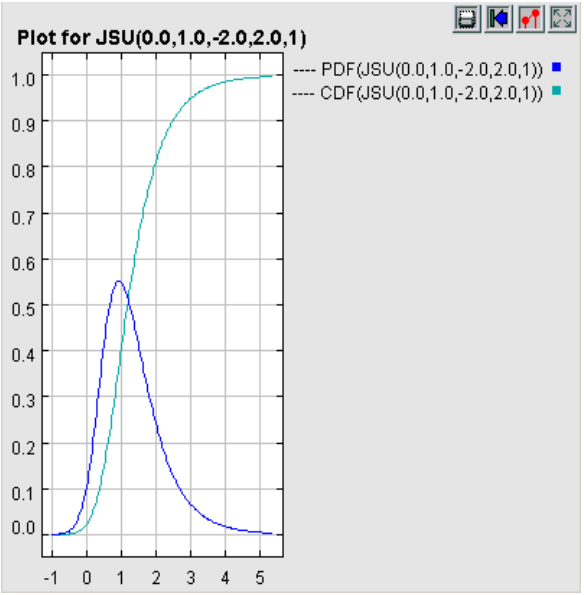


Probability density function and cumulative density function for a Johnson S_B distribution with minimum = 0, maximum = 1, shape1 = 2, and shape2 = 2.

Syntax: JSB(minimum, maximum, shape1, shape2, stream)

The Johnson S_B distribution (continuous) could be used to model the time required to perform some task when the possible values are restricted to the finite interval [**minimum**, **maximum**]. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > 0, **shape1** = 0, or **shape1** < 0, respectively. The Johnson S_B distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details.

Johnson S_U Distribution

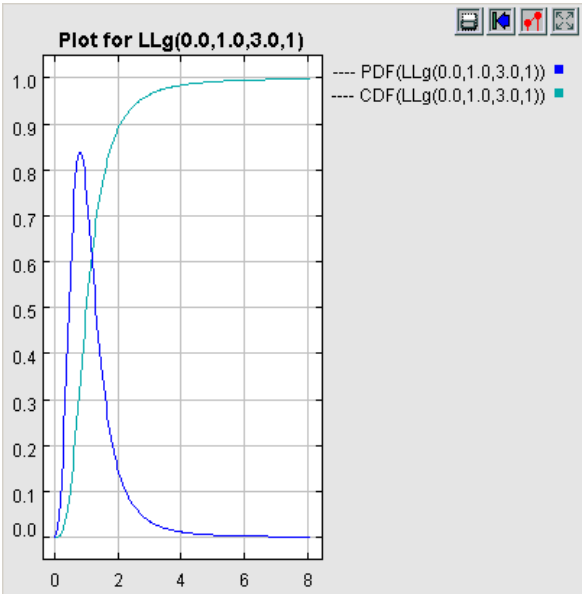


Probability density function and cumulative density function for a Johnson S_U distribution with location = 0, scale = 1, shape1 = -2, and shape2 = 2.

Syntax: JSU(location, scale, shape1, shape2, stream)

The Johnson S_U distribution (continuous) could be used to model a random variable that can take on any value between minus infinity and plus infinity. The density function is skewed to the left, symmetric, or skewed to the right if **shape1** > 0, **shape1** = 0, or **shape1** < 0, respectively. The Johnson S_U distribution is closely related to the classical normal distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details.

Log-Logistic Distribution

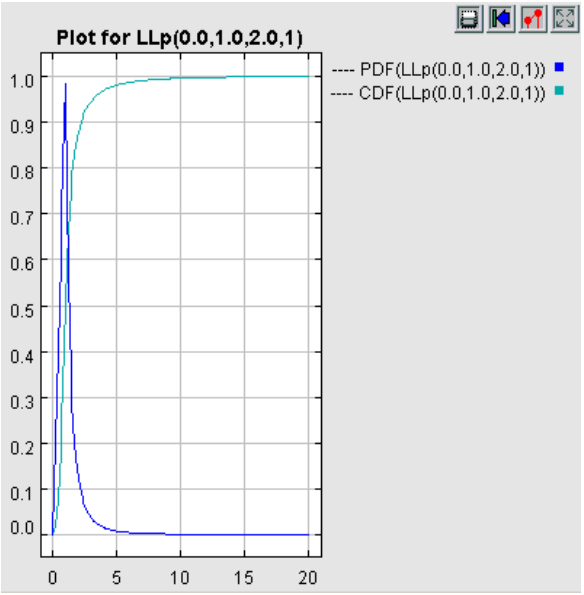


Probability density function and cumulative density function for a Log-Logistic distribution with location = 0, scale = 1, and shape = 3.

Syntax: LLg(location, scale, shape, stream)

The log-logistic distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2.

Log-Laplace Distribution

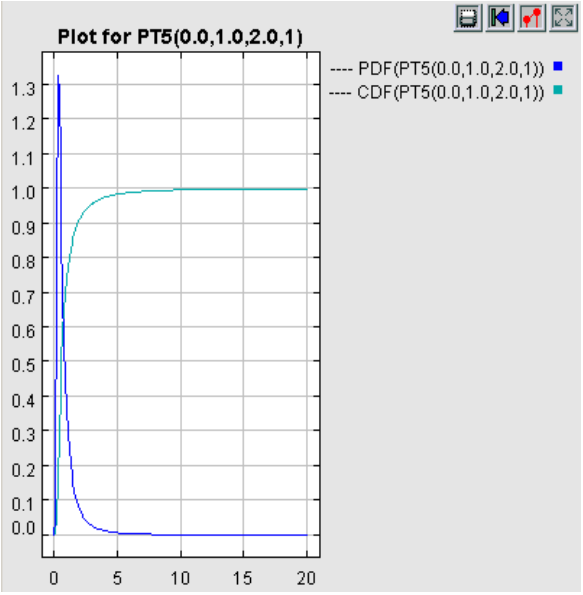


Probability density function and cumulative density function for a log-Laplace distribution with location = 0, scale = 1, and shape = 2.

Syntax: LLp(location, scale, shape, stream)

The log-Laplace distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2.

Pearson Type V Distribution

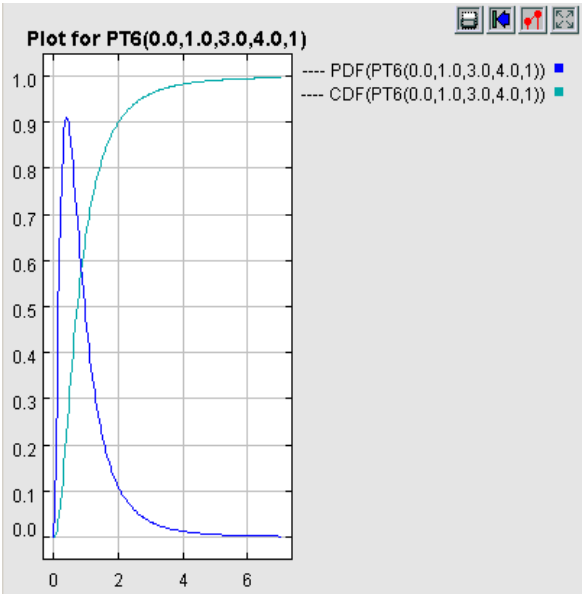


Probability density function and cumulative density function for a Pearson type V distribution with location = 0, scale = 1, and shape = 2.

Syntax: PT5(location, scale, shape, stream)

The Pearson type V distribution (continuous) could be used to model the time required to perform some task. The mean and variance are finite only if **shape** > 2. The Pearson type V distribution is closely related to the gamma distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details.

Pearson Type VI Distribution

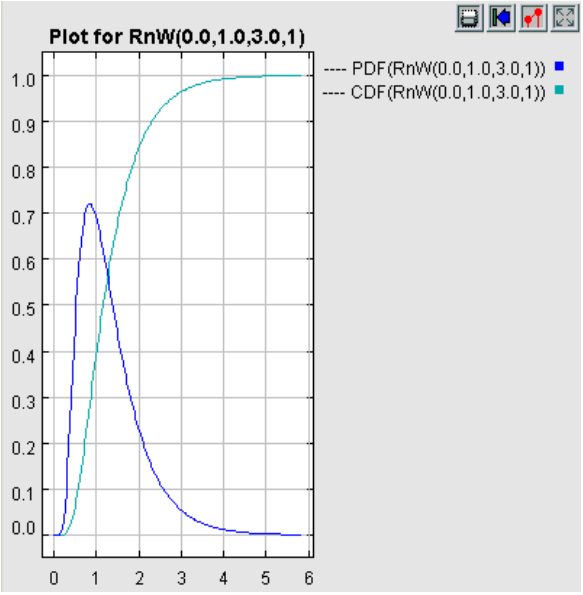


Probability density function and cumulative density function for a Pearson type VI distribution with location = 0, scale = 1, shape1 = 3, and shape2 = 4.

Syntax: PT6(location, scale, shape1, shape2, stream)

The Pearson type VI distribution (continuous) could be used to model the time required to perform some task. The density function can take on a wide variety of shapes because it has two shape parameters **shape1** and **shape2**. The mean and variance are finite only if **shape2** > 2.The Pearson type VI distribution is closely related to the beta distribution - see the book *Simulation Modeling and Analysis* (Third Edition) by Law and Kelton (2000) for details.

Random Walk Distribution



Probability density function and cumulative density function for a random walk distribution with location = 0, scale = 1, and shape = 3.

Syntax: RnW(location, scale, shape, stream)

The random walk distribution (continuous) could be used to model the time required to perform some task.

APPENDIX E

Statistical Tools Glossary

Absolute Deviation

The average deviation of the data set from the mean. It is computed using the absolute value of the difference between a data point and the mean, rather than squared differences used in computing the variance.

Alpha

The probability that an estimate of a parameter does not contain the true value. In statistics, this is referred to as Type I error.

Alternate Hypothesis

The complement of the null hypothesis.

Cdf

Cumulative distribution function.

χ^2 goodness of fit test

A goodness of fit test that uses an χ^2 statistic to evaluate the goodness of fit. The χ^2 goodness of fit test creates an empirical distribution for the data. The empirical distribution used is a histogram. The height of each bin of the histogram is equal to the number of points in the data set that fall between the lower and upper bounds of the bin. The χ^2 statistic is computed as the sum of squared differences of the values observed for each bin of the histogram to the number of observations expected from the probability distribution over the same range as the bin.

Confidence Interval

An interval that contains the true value of a parameter with a given probability.

Continuous Domain

A domain whose variables can take on any value in an interval (real numbers). Integer domains are sometimes interpreted as continuous domains with the implicit assumption that the integers represent an underlying continuous domain.

Data Set

A vector (or equivalently, an array or column) of data points that are the realization of a random process.

Degrees of Freedom

The number of independent elements in a statistical computation. The degrees of freedom must be known to compute the probability of a test statistic such as the χ^2 statistic.

Dof

Acronym for degrees of freedom.

Enumeration Domain

A domain whose range is the set of elements in the enumeration.

Goodness of fit test

A statistical test used to determine the probability that an observed data set came from a probability distribution. The null hypothesis is that the data set is drawn from the probability distribution. The alternate hypothesis is that the data set is not drawn from the probability distribution. A test statistic is computed to evaluate the hypothesis. If the probability of observing the test statistic is small (less than alpha), the fit is rejected.

IID

Identically and independently distributed. In simulation, identical means that observations are made from a hypothesized distribution of values that does not change over simulated time. Independent means that observations of one replication are not correlated with other observations, i.e., if one observation has a value of X, then the next observation is probably close to X.

Image Editor

An editor that contains graphs, tables, or text for viewing the results of a statistical analysis.

Integer-valued Domain

A domain whose range is the set of integer numbers.

KS

Acronym for Kolmogorov-Smirnov.

KS goodness of fit test

A goodness of fit test that uses the D statistic to evaluate the goodness of fit. The KS goodness of fit test creates an empirical distribution for the data. The empirical distribution assigns a probability of 1/N to each data point where N is number of data points in the data set. The D statistic is computed as the maximum difference between the cumulative distribution function of the empirical distribution and the cumulative distribution function of the probability distribution being tested.

Kurtosis

Characterizes the relative peakedness or flatness of a distribution relative to the normal distribution. A data set with positive kurtosis has a sharper peak than a normal distribution, while a data set with negative kurtosis has a flatter peak than the normal distribution.

Maximum Likelihood Estimate

A statistical technique for estimating the parameters of a hypothesized distribution of a data set.

Mean

Average value of a data set.

MLE

Acronym for maximum likelihood estimate.

Mode

The mode of a probability distribution is the value of X where it takes on its maximum value. If the distribution is multiply-peaked, there may not be a unique mode.

Model Element

A named object in the simulation model that has one or more simulation input variables that can be designated as factors for an experiment. The model elements include Activities, Resources, and Entity types.

Pdf

Probability density function.

Performance Measure.

An output statistic that quantifies some behavior of the model.

Percentiles

In a data set ranked by value of the data points, a percentile refers to the data point at the relative position by rank of the data point in the data set. For example, in a data set of a hundred points, the 75^{th} percentile (75%) point is the data point that is in the 75^{th} position when ranked by value.

Quartile Range

Difference between the 25^{th} percentile value and 75^{th} percentile value of the data set.

Range

Difference between the minimum and maximum values of a data set.

Real-valued Domain

A domain whose range is the set of real numbers.

Residuals

The differences between the actual values observed and the expected values as computed by a statistical test.

Sample Domain

A domain whose range is the set of probability distributions supported by SIMPROCESS.

Skewness

Characterizes the degree of asymmetry of a distribution around its mean. A data set with positive skewness has a long tail to the right of its mean. A data set with negative skewness has a long tail to the left of its mean.

Standard Deviation

Square root of the variance.

Standard Error

A measure of the spread of the data set about the mean. Typically, standard error is the one sigma error about the mean of the data set computed as the standard deviation divided by the square root of the number of data points.

Variance

Variability of data set about the mean.

APPENDIX F

SIMPROCESS System Attributes and Methods

Chapter 10 discussed user defined attributes. SIMPROCESS also includes numerous predefined System Attributes and Methods. Each are listed along with a description. Also, there are examples for several of the System Methods.

System Attributes

This section lists all the SIMPROCESS system attributes in a table and provides examples of system methods.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
System Level[b]	Model	Get	OBJECT	Reference of the Model being simulated.
	Self	Get	OBJECT	Reference of the Model Element itself.
	Replication	Get	INTEGER	Current replication number.
Entity Type	Name	Get	STRING	Name of the Entity.
	Priority	Both	INTEGER	Default priority for Entity instances of this type.
	NumberIn	Get	INTEGER	Number of Entity instances of this type currently in the system.
	NumberCreated	Get	INTEGER	Number of Entities instances generated for this type.
	NumberDisposed	Get	INTEGER	Number of disposed Entities instances of this type.
	Interrupt	Both	BOOLEAN	Determines whether Entity instances of this type will interrupt the processing of a lower priority Entity.
Entity (instance)	Name	Get	STRING	Name of this Entity.
	Activity	Get	OBJECT	Reference of Activity this Entity instance resides in.
	BatchSize	Get	INTEGER	Number of Entity instances in this Entity's batch.
	CreateTime	Get	REAL	Time the Entity instance was created.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	EndWait	Both	BOOLEAN	TRUE if Entity wait for Resources was interrupted by MaxWait time.
	EnterTime	Get	REAL	Time the Entity instance entered the current Activity.
	HasParent	Get	BOOLEAN	TRUE if the Entity instance was created by a Split Activity.
	MaxWait	Both	REAL	Maximum time Entity will wait for Resource allocation. Default is 0.0 (unlimited).
	NumberIn	Get	INTEGER	Number of Entity instances of the same type currently in the system.
	NumberCreated	Get	INTEGER	Number of Entity instances of the same type has generated.
	NumberDisposed	Get	INTEGER	Number of Entity instances of the same type has disposed.
	Parent	Get	OBJECT	Returns the Parent Entity instance of this Entity instance. An Entity instance only has a Parent when it was created by a Split Activity. The original Entity instance entering the Split Activity is the Parent.
	Priority	Both	INTEGER	Priority of this Entity instance.
	SequenceNum	Get	INTEGER	A unique number given to each Entity as it is created.
	Type	Get	OBJECT	Entity Type reference of this Entity instance.
	Interrupt	Both	BOOLEAN	Determines whether this Entity instance will interrupt the processing of a lower priority Entity.
Resource	Name	Get	STRING	Name of the Resource.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	Activity	Get	OBJECT	Reference of Activity currently trying to assign or free this Resource (if any).
	Capacity	Get	REAL	Resource capacity.
	Entity	Get	OBJECT	Reference of current Entity instance being processed by the Activity trying to assign this Resource (if any).
	UnitsBusy	Get	REAL	Number of units of the Resource in busy state.
	UnitsDown	Get	REAL	Number of units of the Resource not available because of the application of a downtime.
	UnitsIdle	Get	REAL	Number of units of the Resource in idle state.
Activity's Group I	Name	Get	STRING	Name of this Activity.
	Parent	Get	OBJECT	Reference of this Activity's parent process.
	Entity	Get	OBJECT	Reference of the current Entity.
	Sibling(name: STRING)	Get	OBJECT	It returns the reference to the Activity or process with the specified name in the same hierarchical level.
Activity's Group II	NumberAccepted	Get	INTEGER	Number of Entities so far entered this Activity.
	NumberReleased	Get	INTEGER	Number of Entities exited this Activity.
	NumberIn	Get	INTEGER	Number of Entities currently at this Activity.
Activity's Group III	LastDelay	Get	REAL	The value of the last delay.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	NextDelay	Set	REAL	Change the value of the next delay ONLY.
	AllFutureDelays	Set	REAL	Change the value of all future delays henceforth.
Assemble	Group I, II, & III			
	Activated-ByNoMatch	Get	BOOLEAN	Checks if the expression is activated by an Entity exiting through the NoMatch Pad.
	ActivatedByTrig-ger	Get	BOOLEAN	Checks if the expression is activated by an Entity entering from the Trig-ger Pad.
Assign	Group I, II, & III			
Batch	Group I, II, & III			
	MaxBatchSize	Both	INTEGER	Number of Entities to batch.
	MinBatchSize	Both	INTEGER	Number of Entities must be in a batch before it can be released.
	MaxWaitTime	Both	REAL	Time to wait before releasing under-size batch.
Branch	Group I, II, & III			
	BranchName	Set	STRING	Name of the Connector to be taken by the next Entity.
Clone	Group I, II, & III			
	NumOutEntities	Both	INTEGER	Number of Entities to output per Con-nector.
Delay	Group I, II, & III			
Dispose	Group I & II			
	MaxCount	Both	INTEGER	Number of Entities disposed to signal End Simulation event.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
	NumberDisposed	Get	INTEGER	Number of Entities so far disposed at this Activity.
Free Resource	Group I & II			
Gate	Group I, II, & III			
	ActivatedByTrig-ger	Get	BOOLEAN	Checks if the expression is activated by an Entity entering from the Trig-ger Pad.
	AutoRelCount	Both	INTEGER	Number of Entities for threshold release.
	AutoRelease	Both	BOOLEAN	Whether threshold release is on.
	LastRelCount	Get	INTEGER	Number of Entities released in the previous threshold/trigger release.
	TrigNextRel-Count	Both	INTEGER	Value of the trigger release quantity at the next trigger.
	TrigFutureRel-Count	Set	INTEGER	Change the trigger release quantity for all future triggered release hence-forth.
Generate	Group I			
	NumberGener-ated	Get	INTEGER	Number of Entities generated at this Activity.
Get Resource	Group I & II			
Join	Group I, II, & III			
Merge	Group I & II			
Process	Group I & II			
	Child(name : STRING)	Get	OBJECT	For hierarchical processes ONLY. It returns the reference to the child Activity or process with the specified name.

SIMPROCESS System Attributes

Model Elements	Attribute Name[a]	Get/ Set	Attribute Type	Description
Replenish Resource	Group I & II			
Split	Group I, II, & III			
Synchronize	Group I, II, & III			
Transform	Group I, II, & III			
	NumOutEntities	Both	INTEGER	Number of output Entities.
	OutEntityType	Both	OBJECT	Reference of output Entity Type.
Unbatch	Group I, II, & III			

a. System attributes' names must be input as shown. They are case sensitive.
b. Attributes in this category can be referenced in any expression.

SIMPROCESS System Methods

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ActivateGenerate	Generate Name: STRING	NONE	If not already started, starts the generation of Entities by the specified generate activity.
ACOS	X: REAL	REAL	Returns the ACOSine of X.
Alert	MasterEditor[b], Message: STRING	NONE	Display a message in the **Alert** dialog and wait for the user to close this dialog.
ASIN	X: REAL	REAL	Returns the ASine of X.
ATAN	X: REAL	REAL	Returns the ATANgent of X.
ATAN2	Y: REAL, X: REAL	REAL	Returns the ATANgent of X and Y.
CEIL	X: REAL	REAL	Returns the smallest integer not less than X.
Beep	MasterEditor[b]	NONE	Makes a beep sound.
ChangeColor	ActName: STRING, Color: STRING	NONE	Changes the color of the specified Activity. Entity references are no longer allowed. The keywords Self, Activity, and Parent or the name of an activity is allowed for ActName. Note that a keyword must be input as a STRING (such as “Self”).
CloseDatabase	Database Connection: OBJECT	NONE	Closes the specified database connection.
CloseFile	File Stream: OBJECT	NONE	Closes the specified file.
CloseSpreadsheet	File Stream: OBJECT	NONE	Closes the specified spreadsheet file.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
Confirm	MasterEditor[b], Message: STRING	BOOL-EAN	Displays a message in the **Confirm** dialog and waits for the user to respond; **OK** returns TRUE, **CANCEL** returns FALSE.
COS	X: REAL	REAL	Returns the COSine of X.
DateTime	None	STRING	Returns the current date and time of the simulation in MM/DD/YYYY HH:MM:SS:MSEC:USEC:NSEC format.
DecreaseCapacity	Resource Name: STRING Units: INTEGER or REAL	NONE	Decreases the capacity of a Resource by the units specified.
DrawIntegerSample	Statistical Distribution: STRING	INTE-GER	Draws a sample of type integer from the specified statistical distribution.
DrawRealSample	Statistical Distribution: STRING	REAL	Draws a sample of type real from the specified statistical distribution.
ElapsedTime	Units (Optional): STRING Start: STRING End: STRING	REAL	Returns the amount of time between the Start value and End value. The Units is optional and can be any valid time unit ("Seconds," "Minutes," etc.). If omitted, the value returned is in the units set by **Simulation Time Unit** in **Run Settings**. Start and End use the format MM/DD/YYYY HH:MM:SS:MSEC:USEC:NSEC. The formats MM/DD/YY and YYYY-MM-DD can also be used for the date portion of Start and End. The **DateTime** function can be used for Start or End.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
EXP	X: REAL	REAL	Returns e raised to the power of X.
ExternalCall	Class Name: STRING Method Name: STRING Method Parameters (as required by external method): INTEGER, REAL, STRING, BOOLEAN	BOOLEAN, REAL, INTEGER, or STRING	Executes a method of an external Java class. Assumes the class is in the **`ext`** directory or in a properly constructed jar file in the **`jre/lib/ext`** directory. Errors in the calls will result in an aborted simulation. Note: To use this call you must have purchased the External Application Interface plug-in license from CACI.
FireTrigger	Activity Name: STRING	NONE	Fires the trigger of the specified Gate or Assemble Activity.
FLOAT	Number: INTEGER	REAL	Converts the argument to REAL.
FLOOR	X: REAL	INTEGER	Returns the largest integer not greater than X.
FreeResource	Resource Name: STRING Tag (Optional): STRING Consume (Optional): BOOLEAN	NONE	Creates a free Resource request for an Activity.
Function	Function Name: STRING	REAL	Returns the value of a User-defined Function.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GenerateEntity	Generate Name: STRING Entity Name (Optional): STRING Quantity (Optional): INTEGER	NONE	Generates Entities from the specified Generate Activity. If Entity Name is not specified, the default defined for Entity Type in the specified Generate Activity is used. If Quantity is not specified, the default Quantity in the specified Generate Activity is used. Quantity can be specified without an Entity Name, and Entity Name can be specified without a Quantity.
GetActivityStatistic	Activity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Activity Name** statistic. **Statistic** is one of the statistics types for Activities listed in the Labels column of the table in Appendix G. (See "Statistic Types" on page 507.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetActivityByEntityStatistic	Activity Name: STRING Entity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Activity Name** and **Entity Name** statistic. **Statistic** is one of the statistics types for Activities listed in the Labels column of the table in Appendix G. (See "Statistic Types" on page 507.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." The value for **Replication** cannot be larger than the current replication simulating. A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.
GetAttributeStatistic	Attribute Name: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Attribute Name**. **Attribute Name** must be unique among the attributes that are being statistically monitored. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetCostStatistic	Period Name: STRING Cost Object 1: STRING Cost Object 2: STRING Cost Type: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Period Name**, **Cost Object 1**, and **Cost Object 2**. **Cost Object 1** can be the name of a Resource or an Activity. **Cost Object 2** can be the name of an Activity or an Entity. Thus, the combination of **Cost Object 1** and **Cost Object 2** can be "Resource and Entity," "Resource and Activity," or "Activity and Entity." **Cost Type** options are "Capacity" or "Absorption". **Value Type** is either "Avg," "StDev," "Min," or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for **Value Type**. A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.
GetEntityStatistic	Entity Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Entity Name** statistic. **Statistic** is one of the statistics types for Entities listed in the Labels column of the table in Appendix G. (See "Statistic Types" on page 507.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetNext	Result Set Name: STRING	BOOL-EAN	Used to advance to the next row of a Result Set. Returns TRUE if the Result Set has more values.
GetResource	Resource Name: STRING Units: STRING, INTEGER, or REAL Tag (Optional): STRING	NONE	Creates a get Resource request for an Activity.
GetResourceStatistic	Resource Name: STRING Statistic: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Resource Name** statistic. **Statistic** is one of the statistics types for Resources listed in the Labels column of the table in Appendix G. (See "Statistic Types" on page 507.) **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.
GetResourceByAc-tivityStatistic	Resource Name: STRING ActivityName: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the requested **Resource Name** and **Activity Name** statistic. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "Run-Length." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
GetResult	Result Set Name: STRING Database Field: STRING	INTEGER, REAL, BOOLEAN, STRING	Returns a value from a Result Set. Type of value returned is dependent on the type of values in the requested field of the Result Set.
GetTimeStampStatistic	Start Key: STRING StopKey: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the value of the Time Stamp with **Start Key** and **Stop Key**. **Value Type** is either "Avg," "StDev," "Min," "Max," "Count," or "RunLength." A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.
GetTotalCostStatistic	Resource Name: STRING Cost Type: STRING Value Type: STRING Replication: INTEGER	REAL	Returns the total cost for the requested **Resource Name**. If **Resource Name** is "Total," then the total cost of all Resources is returned. **Cost Type** is either "Capacity" or "Absorption." **Value Type** is either "Avg," "StDev," "Min," or "Max" for **Replication** -1. If **Replication** is 1 or greater, the maximum value is returned no matter what is entered for **Value Type**. A **Replication** of -1 returns the average of replications, and a value of -2 returns the sum of replications.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
HALT	Message (Optional): STRING	NONE	If used with no parameters, it ends the current replication and simulation continues with next replication. If parameters are used, the simulation is stopped with an error condition. A dialog appears that contains the contents of the parameter.
IncreaseCapacity	Resource Name: STRING Units: INTEGER or REAL	NONE	Increases the capacity of a Resource by the units specified.
INTTOSTR	number: INTEGER	STRING	Converts an integer number to a string.
LN	X: REAL	REAL	Returns the Natural Log of X.
LOG10	X: REAL	REAL	Returns the base 10 Log of X.
MAXOF	list of numbers: REAL/INTEGER (all the numbers in list must be of the same type)	REAL or INTEGER	Returns the maximum number in the given list. Return type is the same as the input list.
MINOF	list of numbers: REAL/INTEGER (all the numbers in list must be of the same type)	REAL or INTEGER	Returns the minimum number in the given list. Return type is the same as the input list.
OpenDatabase	Database DSN: STRING or Properties File: STRING UserName (Optional): STRING Password (Optional): STRING	OBJECT	Creates a connection to the database specified by the DSN. The DSN for the database is specified in the ODBC control panel. The UserName and Password are optional. However, if UserName is used, Password must also be used. When not using Windows, the Properties File is the name of the file that specifies the URL and protocol to use.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
OpenFile	Mode: STRING File Name: STRING	OBJECT	Open the specified file and return the file stream object. Mode can be “input” or “output.” The File Name String can contain physical path names if the user wants to explicitly tell SIMPROCESS where the file resides. If path separators (e.g., / or x: in Windows) are used, the program assumes the user is providing a complete and valid physical file path. If no path separators are detected in the file name, the Model’s folder is where the files will reside. Note that double backslashes (\\) must be used in file paths instead of a single backslash.
OpenSpreadsheet	Mode: STRING File Name: STRING	OBJECT	Open the specified spreadsheet file and return the file stream object. Mode can be “input” or “output.” The File Name String can contain physical path names if the user wants to explicitly tell SIMPROCESS where the file resides. If path separators (e.g., / or x: in Windows) are used, the program assumes the user is providing a complete and valid physical file path. If no path separators are detected in the file name, the Model’s folder is where the files will reside. Note that double backslashes (\\) must be used in file paths instead of a single backslash.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
OUTPUT	Takes zero or more arguments separated by commas. Type can be REAL, BOOLEAN, INTEGER, or STRING	NONE	Display the specified arguments in the **Output** dialog. Functions (including nested functions) that result in any of the argument types can be used in the OUTPUT statement.
POSITION	String1: STRING String2: STRING	INTEGER	This method returns the starting position of String2 in String1. If String2 is not completely contained in String1, it returns 0.
POWER	X: REAL, Y REAL	REAL	Returns X raised to the power of Y.
READ	INTEGER, REAL, STRING, or BOOLEAN	INTEGER, REAL, STRING, or BOOLEAN.	Reads a single variable into an identifier from a dialog prompt. The name of the identifier will be presented in the dialog for the user, and the value entered will be validated (i.e., INTEGER type must be an integer value).
ReadFromDatabase	Database Connection: OBJECT Result Set Name: STRING SQL Statement: STRING	NONE	Reads values based on the SQL Statement from the database specified by the connection. The values are placed in a Result Set with the given Result Set Name. The Result Set Name should be unique for each ReadFromDatabase unless a Result Set is to be replaced.
ReadFromFile	File Stream: OBJECT List of variables	NONE	Read values for the listed variables from the input file associated with the specified File Stream.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ReadFromSpread-sheet	File Stream: OBJECT Sheet Name: STRING Row: INTEGER Column: INTEGER Variable: STRING, INTE-GER, REAL, or BOOLEAN	NONE	Read a value from the specified sheet, row, and column of the in-put spreadsheet file associated with the specified File Stream. The value is assigned to Variable.
REALTOSTR	number: REAL precision: INTEGER (Option-al)	STRING	Converts a real number to a string. If a precision is specified, the number is rounded to the specified precision. Trailing ze-roes are added if the decimal part of the number is less than the specified precision.
RemoteCall	Server URL: STRING Server Name: STRING Method Name: STRING Method Parameters (as re-quired by remote method): IN-TEGER, REAL, STRING, BOOLEAN	BOOL-EAN	Executes a method of a remote application. Assumes a Java RMI server has been registered with the objects and methods being called. Errors in the calls will re-sult in an aborted simulation. Note: To use this call you must have purchased the External Ap-plication Interface plug-in license from CACI.
REPLACE	String1: STRING position1, position2: INTE-GER String2: STRING	STRING	Returns a string that is in String1 with part of String1 from position 1 to position 2 replaced with String2.
Resource	ResourceName: STRING	OBJECT	Returns the reference to the spec-ified Resource.
ROUND	number: REAL	INTE-GER	Rounds the argument and returns the closest integer value.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
ShowSystemAttributes[c]	None	NONE	Display all the System-Defined Attributes of the calling element and any related elements that are within scope (i.e., if this function is called on the Activity expression, then the system attributes for any Entity or Resource elements will also be included) in the **Output** dialog.
ShowUserAttributes[c]	None	NONE	Display all the User-Defined Attributes evaluated for the calling elements and any related elements that are within scope (i.e., if this function is called on the Activity expression, then the user-defined attributes for any Entity or Resource elements will also be included) in the **Output** dialog.
SimTime	Timeunit (Optional): STRING Valid time units are - Years, Months, Weeks, Days, Hours, Minutes, Seconds, Milliseconds, Microseconds, Nanoseconds. Time unit strings are case sensitive.	REAL	Return current simulation time in time units specified. If no parameter is provided, time unit defaults to the Simulation Time Unit set in the Run Settings.
SIN	X: REAL	REAL	Returns the Sine of X.
SQRT	X: REAL	REAL	Returns the square root of X.
STATUS	Same as OUTPUT	NONE	Display the specified arguments in status bar.
STRLEN	inString: STRING	INTEGER	Returns the length of the string, inString.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
STRTOINT	inString: STRING	INTEGER	Converts a string consisting only of numbers with no decimal in the string to an integer.
STRTOREAL	inString: STRING	REAL	Converts a string of numbers including a decimal to a real.
SUBSTR	position1, position2: INTEGER String: STRING	STRING	Returns the substring of String from position1 to position2, inclusive.
SystemTime	None	REAL	Returns the current system time in milliseconds.
TAN	X: REAL	REAL	Returns the TANgent of X.
TRUNC	number: REAL	INTEGER	Returns the integer part of the number
UpdateDashboardLabel	Dashboard Name: STRING Host or IP Address: STRING Port: INTEGER TextLabel Name: STRING Value: INTEGER, REAL, STRING or BOOLEAN	NONE	Update the specified TextLabel with the given value.
UpdateDynamicLabel	MasterEditor[b] Label Name: STRING Label ID: INTEGER Font Color: STRING Value: Same as Label's Mode	NONE	Update the specified dynamic label with the given value.
WriteToDatabase	Database Connection: OBJECT SQL Statement: STRING	NONE	Used to modify tables of the database specified by the connection. The SQL Statement should be of type INSERT, DELETE, or UPDATE.
WriteToFile	File Stream: OBJECT list of variables	NONE	Write the values of the listed variables to the output file specified by the File Stream.

SIMPROCESS System Methods

Method Name[a]	Arguments	Return	Description
WriteToSpreadsheet	File Stream: OBJECT Sheet Name: STRING Row: INTEGER Column: INTEGER Variable: STRING, REAL, INTEGER, or BOOLEAN	NONE	Writes the value of Variable to the specified sheet, row, and column of the output spreadsheet file specified by the File Stream.

a. System methods' names must be input as shown. They are case sensitive.

b. This argument (i.e., MasterEditor) must be the first argument inside the parentheses of this method. It is required by the method and must be input as shown. It is case sensitive.

c. Since this method does not require any argument, do not include empty parentheses when using this method.

System Method Examples

Method Alert and Beep:

For example, to display a message and sound alarm when an Entity enters an Activity, put the following lines in the Activity's **Accept Entity** event:

```
Beep(MasterEditor);
Alert(MasterEditor, "Press OK to continue!");
```

Method Confirm, DrawRealSample, MINOF, MAXOF, and REALTOSTR:

This example demonstrates the syntax and usage of the listed methods. It draws a number from a Uniform distribution whose minimum and maximum parameters are results from an Exponential distribution with a mean of 30. The result is displayed in a message box with **OK** and **Cancel** buttons. Pressing **OK** will continue this process again, while **Cancel** will end the process.

```
fContinue : BOOLEAN;
value1, value2, maxval, minval : REAL;

fContinue := TRUE;
WHILE fContinue
value1 := DrawRealSample("Exp(30.0)");
value2 := DrawRealSample("Exp(30.0)");
maxval := MAXOF(value1, value2);
minval := MINOF(value1, value2);
value1 := DrawRealSample("Uni("+REALTOSTR(minval)+"," +REAL-
   TOSTR(maxval)+")");
Beep(MasterEditor);
fContinue := Confirm(MasterEditor, "The value is "+ REAL-
   TOSTR(value1));
END WHILE;
```

Method ChangeColor:

This method changes the color of a non-bitmap icon. Currently, Activity icon "RectangleIcon," and Process icon "DefaultIcon" can change color. The "SIMPROCESS Color Table," beginning on page 497 contains the 64 colors available in SIMPROCESS. The name of an Activity or Process can be specified, or "Self", "Parent", or "Activity" can be used to designate the Activity or Process. Note

that in earlier versions of SIMPROCESS (pre 4.1), “Self”, “Parent”, and “Activity” did not require quotes. Earlier version models using those keywords must be modified to include quotes for use with SIMPROCESS 4.1 or later versions. If an Activity or Process name is used, SIMPROCESS will attempt to change the color of every Activity or Process that matches the input name.

The following changes the color of the Activity Delay4 to Red.

```
ChangeColor(“Delay4”, “Red”);
```

The following changes the color of the current Activity or Process to Blue.

```
ChangeColor(“Self”, “Blue”);
```

The following changes the color of the parent Process of the current Activity or Process to Yellow.

```
ChangeColor(“Parent”, “Yellow”);
```

The ability to change colors of Entities is no longer supported. For example, the following code will now produce an error.

```
ChangeColor(Entity, “Brown”);
```

To change the color of the Activity icon to green if there is no Entity in it, in the Activity’s **Release Entity** event add:

```
IF (NumberIn = 0)
   ChangeColor(“Self”, “Green”);
END IF;
```

Method ShowSystemAttributes and ShowUserAttributes:

These methods display all the system-defined and user-defined attributes with their current values of the calling element in the standard output window. For example, to display the system-defined attributes of an Activity when an Entity enters, in the Activity’s **Accept Entity** event put:

```
ShowSystemAttributes;
```

All the system-defined attributes and values are listed in the standard output window. In addition, any

related elements' system attributes or user-defined attributes will be listed in the output window as well. For example, if the ShowUserAttributes method is called from the expression script in an Activity event (such as Accept Entity), the Entity that is within scope will also have its user-defined attributes listed. The same goes for Resources being assigned.

Model level user-defined attributes are listed no matter what elements are within scope.

Method SimTime:

This method returns the current simulation time in hours unless a time unit parameter is provided. The return value is **REAL** type. For example:

```
Entity.StartTime := SimTime; { StartTime is a REAL global
   Entity instance attribute of type REAL. }
```

The allowable time units are provided as a string parameter and are case sensitive. The allowable time units are: Years, Months, Weeks, Days, Hours, Minutes, Seconds, Milliseconds, Microseconds, Nanoseconds. An example using the time units is as follows:

```
Mytimeunit : STRING;
Mytimeunit:="Weeks";
OUTPUT("My time unit in weeks = ",
    SimTime(Mytimeunit);
OUTPUT("My time unit in months = ",
    SimTime("Months");
```

Method OUTPUT and STATUS:

To display a message in the standard output window:

```
OUTPUT(“Number of orders currently held in Gate10 is : “, Num-
   berIn);

realnum : REAL;

OUTPUT(“The String value of realnum = “,

   REALTOSTR(realnum));
```

Or, to display it in the status bar:

```
STATUS("Number of orders currently held in Gate10 is : ", Num-
   berIn);
```

where the expressions above are placed on the Activity, Gate10.

Method UpdateDashboardLabel:

To use this method, you need to assign a Dashboard to your model which contains a TextLabel. To assign Dashboards, refer to "Assigning Dashboards," beginning on page 390.

Five arguments are required for this method. The first is **`Dashboard Name`**. This is the name used when you assigned the Dashboard to your model. You may also use the name of the Dashboard's file (without any path and without the ".spd" extension), although this is not recommended since it negatively impacts performance. The second argument is the **`Host or IP Address`** where a Dashboard Server is expected to be receiving messages for the assigned Dashboard. This value must match the one entered when the Dashboard was assigned. It is important to note that SIMPROCESS compares the values and not their meanings. While **`localhost`** and **`127.0.0.1`** refer to the same system (i.e., they have the same meaning), they are not the same values to SIMPROCESS. The third argument is the **`port`** on which a Dashboard Server is expected to be receiving messages for the assigned Dashboard. This value must also match the one entered when the Dashboard was assigned. The fourth argument is the name of a Graph on the assigned Dashboard of type TextLabel. The name is an uneditable field displayed on the properties dialog for the TextLabel when assigning a Dashboard and will be unique for that Dashboard. The fifth argument is the value to be displayed on the TextLabel. It can be of type **`INTEGER`**, **`REAL`**, **`STRING`** or **`BOOLEAN`**.

For example, the `Call Center` model has assigned the `Call Status.spd` Dashboard file using the name `Call Status`. The assigned Dashboard designated a Server Address of `localhost` and port `5555`. This Dashboard contains a TextLabel by the name of `TextLabel4`. During simulation, you want to display the number of Entities generated at a Generate Activity. In the Release Entity expression of the selected Generate Activity add the following line:

```
UpdateDashboardLabel("Call Status", "localhost", 5555,
   "TextLabel4", NumberGenerated);
```

While this statement may be used with any TextLabel on any assigned Dashboard, it is best used with those that have no Plot Values assigned to it. In that way, you may be certain that the value you place on the TextLabel via this statement will remain unchanged until a subsequent statement updates it.

Method UpdateDynamicLabel:

To use this method, you need to define a dynamic label in the work area first. To define a dynamic label, refer to "Dynamic Labels," beginning on page 258.

Five arguments are required for this method. The first one is **`MasterEditor`**. This is the key word that must be there and input as shown. The next two arguments are the **`Name`** and **`ID`** of the dynamic label defined in the **Background Text Properties** dialog. The fourth argument is the color to be used in displaying this label. The last argument is the value to be displayed. It can be a constant or an attribute, but the data type must match the **Mode** defined in **Background Text Properties**.

For example, you want to display the number of Entities generated at a Generate Activity. Assume you have already defined a dynamic label with the name "total," ID of 0, and data type of INTEGER. In the Release Entity event of the Generate Activity add the following line:

```
UpdateDynamicLabel(MasterEditor, "total", 0, "DarkBlue", Num-
   berGenerated);
```

The first parameter of this method must be **`MasterEditor`** and input as shown.

Methods OpenFile, CloseFile, ReadFromFile, and WriteToFile:

OpenFile opens the file specified in the **Filename** field for either input or output. The mode must be either "input" or "output" (not case-sensitive). "Input" opens a file to read, while "output" opens a file to write. Any other specifications will lead to an error message. Both arguments are STRING type, i.e., they must be surrounded by quotation marks. **OpenFile** returns an Object type value which is required in **CloseFile, ReadFromFile**, and **WriteToFile** methods.

```
OpenFile(Mode, Filename) : OBJECT;
```

By default, SIMPROCESS will look for either input or output files in the directory of the active model. Either file can be placed elsewhere as long as the path is specified in the **OpenFile** statement. Note that double backslashes (\\) must be used instead of single backslashes (\) in file paths.

The following example opens a file (`myoutput.dat`) for output. First, define a Model Attribute **MyOutStream** that is type Object. If the file is to be opened in the Start Run expression, make sure that **Do Not Reset Before Each Replication** is selected on the attribute properties dialog. If the file is opened in the Start Simulation or Start Trial expression, the file will be opened each replication. Type the following statement in one of the expressions.

```
Model.MyOutStream := OpenFile("Output", "myoutput.dat");
```

The next example opens a file (`myinput.dat`) for input and keeps the return value in the model attribute **MyInStream**.

```
Model.MyInStream := OpenFile("input", "myinput.dat");
```

ReadFromFile reads the specified numbers of values from a file that is open for input. The first argument is the input stream, from a previous **OpenFile** call (the file must be open for input). From the previous example, the model attribute, **Model.MyInStream** would be the input stream. Following the stream argument is a list of variables whose values are going to be read in from the file.

```
ReadFromFile(Input Stream, List of
   variables);
```

In the input file, values should be separated by one or more white spaces (i.e., space, tab, or new line characters). There is also a pre-defined special delimiter "|" in SIMPROCESS. You can use "|" to separate values. This delimiter is very useful to separate values (strings) that contain any white space. You can surround the whole string with a pair of "|"s, and **ReadFromFile** will read in whatever is in between as one value.

The input file can contain comments. Any characters that follow double forward slashes (**//**) will be ignored.

The type of value to be read in is dependent on the specified variable type. A mismatch will cause an error. The following table shows the valid types for different value types. Integer and real are any

valid numerical values. **ReadFromFile** will either truncate a real value to integer for an Integer type variable, or float an integer value to real for a Real type variable. String is a sequence of characters. If spaces are included, surround the whole string with "|". Boolean can only be either TRUE or FALSE. Any other value will cause an error. Boolean values are not case sensitive.

	Value Types in File			
Variable Types	Integer	Real	String	Boolean
Integer	OK	Truncated	Error	Error
Real	FLOATed	OK	Error	Error
String	OK	OK	OK	OK
Boolean	Error	Error	Error	OK
Object	Error	Error	Error	Error

Example:

The input file contains:

```
|This is a test for ReadFromFile.|

123      67.89    TRUE
```

The expression reads as:

```
StrVal    : STRING;
IntVal    : INTEGER;
RealVal   : REAL;
BoolVal : BOOLEAN;
ReadFromFile(Model.MyInStream, StrVal, IntVal);
ReadFromFile(Model.MyInStream, RealVal, BoolVal);
```

The expression will read in the following:

```
StrVal has the value "This is a test for ReadFromFile.".
```

IntVal has the value **123**.

RealVal has the value **67.89**.

BoolVal has the value **TRUE**.

WriteToFile writes the values of the specified variables to a file that is open for output. The first argument is the output stream, that is the returned value from a previously **OpenFile** call (must be

open for output). Following the stream argument is a list of variables whose values are going to be written to a file.

```
WriteToFile(Output Stream, List of variables);
```

The output values will be written to the file consecutively. Any kind of format or spacing has to be output explicitly by the user. There are two special characters that can be used in formatting outputs: "^" will write a tab to the file, while "/" will advance to a new line. For these to work correctly, they must be written individually and be surrounded by "".

For example:

Following the prior example of **ReadFromFile**, an expression has:

```
WriteToFile(Model.MyOutStream, StrVal, "/", IntVal, "^");
WriteToFile(Model.MyOutStream, RealVal, "^", BoolVal);
```

Write to the file as:

```
This is a test for ReadFromFile.

123      67.89    TRUE
```

CloseFile closes the file the IOStream pointed to.

CloseFile(IOStream);

For example:

```
CloseFile(Model.MyOutStream);
```

CloseFile(Model.MyInStream);

Close the files `myoutput.dat` and `myinput.dat`, respectively.

Typically, you will place **CloseFile** in the End Trial Expression, especially if you put **OpenFile** in the Start Trial Expression.

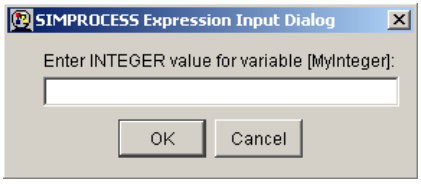
Method READ:

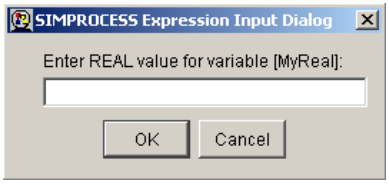
READ prompts the user for a single variable input. The variable must be a locally-defined variable (i.e., a system attribute or a user-defined attribute such as a Model, Activity, Resource, or Entity attribute cannot be referenced directly). Example:

```
MyInteger : INTEGER;
MyREAL : REAL;
READ MyInteger;
READ MyREAL;
```

The above example will provide an input prompt requesting the user to input an integer value for **MyInteger**, and the next read statement will prompt the user to input a REAL value for **MyREAL**. Type checking is done on the values entered so the user should make sure the values are compatible (i.e., don't enter “hello dolly” when prompted to enter an integer). If the value is not compatible, an error exception is thrown and the simulation stops.

The prompts for the above example would look as follows:





Method HALT:

HALT terminates the current replication or simulation. When used with no parameters, the current replication is ended and the next replication begins. This is similar to using the **Maximum Entity Count** on the Dispose Activity. HALT with parameters terminates the simulation in an error condition. The value of the parameters are displayed in an error dialog.

This statement is useful for debugging and stopping simulations at certain conditions in the model when developing a complex model. You may prefer the use of OUTPUT and ALERT statements to notify you of happenings in the model, but the HALT is there if you need it. Example:

HALT; (ends current replication)

HALT("Encountered error in Delay5"); (terminates simulation)

Method RemoteCall:

RemoteCall is a plug-in capability that can be licensed separately from CACI to allow users to make calls to external applications from within the expression scripts of a SIMPROCESS model. This feature is a powerful way to make calls to user applications (either custom developed or commercial products) based on how the business process model and workflow is planned. An example of this might be a model that represents a "To Be" business process flow for Human Resources where you intend to use a commercially available human Resources product such as Peoplesoft, Lawson, or Oracle. Based on specific Activities in the model execution, you could make expression script calls to a user-written server that would "feed" the commercial application as a prototype to see if the product will align with the desired business process needs. The server program could "feed" the application either from native calls to the product or via other interface technologies such as XML. This capability will support analysis using models between the business functions and the system transactions that are required to support them.

The RemoteCall provides the mechanisms to make calls to a Java RMI server that has been registered using the Java RMI Registry. It is the responsibility of the user to develop the RMI server program and start the application. The expression script method simply has to have the name of the server computer (could be the same computer that the model is running on or could be a separate server over the network), the server object to be called, the remote method to call, and the parameter list that matches the remote procedure in the user-written server.

Example:

```
mybool : BOOLEAN;
mybool:=RemoteCall("rmi://localhost/", "server-demo", "putPlot-
 Data", SimTime, Self.NumberAccepted);
```

In the example above, a remote server application (this one happens to be running on the same computer as the model, hence the localhost URL address) called server-demo is looked up using the Java RMI registry, and the putPlotData method is called with two parameters - SimTime and NumberAccepted, where NumberAccepted is the number of Entities accepted in the Activity. (See "System Attributes" on page 459.)

The following is a description of the server application showing the actual Java code needed to implement this example. This text is not a complete reference to RMI programming, and we recommend

you reference any of the many Java-published materials on RMI (java.sun.com is a good place to start).

The following is a list of the source Java programs that demonstrate the RemoteCall interface. The files are located in the **SPUser\SampleFiles** directory.

SPServerDemo.java - defines the server class and the methods that will be called from the expression script. The Java code is as follows

```
package com.caci.demo;

import java.rmi.*;

import java.util.*;

import ptolemy.plot.*;

import ptolemy.plot.plotml.*;


public interface SPServerDemo extends Remote

{  boolean putPlotData(double simtime, int totalEntities )

      throws RemoteException;

   boolean clearData()

      throws RemoteException;

}
```

SPServerDemoImpl.java - defines the implementation code for the server class and methods. This example instantiates a user-defined class that uses the Ptolemy plotting classes. This plot is being presented on the screen to the user by the server program separate from the SIMPROCESS simulation. The data being fed to the plot is coming from the simulation and the RemoteCall parameters shown above. The Java code is as follows:

```
package com.caci.demo;

import java.rmi.*;

import java.rmi.server.*;

import java.util.*;
```

```
import ptolemy.plot.*;
import ptolemy.plot.plotml.*;


public class SPServerDemoImpl
   extends UnicastRemoteObject
   implements SPServerDemo
{
public SPServerDemoImpl()
      throws RemoteException
   {
   myplot = new SPPlotDemo("Number Entities", "Simulation Time
in Hours");
   }
  public boolean putPlotData(double simtime, int totalEntities )
      throws RemoteException
   {
      myplot.putTicks(simtime, totalEntities);
      return true;
   }
   public boolean clearData()
      throws RemoteException
   {
      myplot.clearData();
      return true;
   }
   private String name;
```

```
   SPPlotDemo myplot;
}
```

SPServerDemoServer.java - defines the server binding to the RMI registry. This is necessary for Java client code (such as the RemoteCall in SIMPROCESS) to do a lookup and find the server by a name that was “binded” to the actual server class that is running on the remote server. The Java code is as follows:

```
package com.caci.demo;
import java.rmi.*;
import java.rmi.server.*;
import ptolemy.plot.*;
import ptolemy.plot.plotml.*;

public class SPServerDemoServer
{  public static void main(String args[])
   {  try
      {  System.out.println
            ("Constructing Server implementations...");
         SPServerDemoImpl d1
            = new SPServerDemoImpl();
         System.out.println
          ("Binding server implementations to registry...");
         Naming.rebind("serverdemo", d1);
         System.out.println
            ("Waiting for invocations from clients...");
      }
```

```
        catch(Exception e)
        {  System.out.println("Error: " + e);
        }
    }
}
```

SPPlotDemo.java - defines the plotting class that is instantiated in the SPServerDemoImpl.java class. The Java code is as follows:

```
package com.caci.demo;
import ptolemy.plot.*;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;
import javax.swing.JFrame;

public class SPPlotDemo extends JFrame {
Plot myPlot = null;
boolean first = true;

SPPlotDemo(String yLabel, String xLabel) {
        // Instantiate the plot.
        myPlot = new Plot();
        // Set the size of the toplevel window.
        this.setSize(600, 600);
         myPlot.setSize(550, 550);
        myPlot.setButtons(true);
```

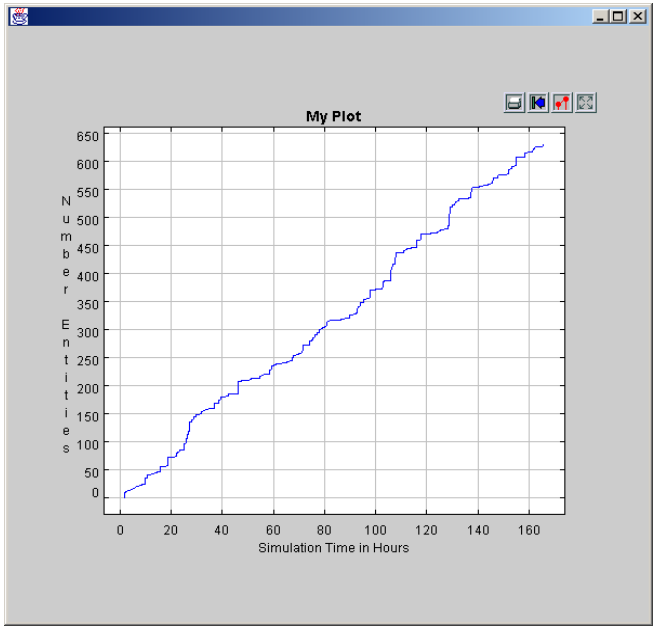
```
            myPlot.setTitle("My Plot");
            myPlot.setXLabel(xLabel);
            myPlot.setYLabel(yLabel);
            myPlot.setYRange(0.0, 1.0);
            myPlot.setXRange(0.0, 20.0);
            myPlot.setMarksStyle("none");
            myPlot.setImpulses(false,1);
      myPlot.setConnected(true,1);
      myPlot.setBars(false);

      myPlot.setSize(350,300);
            GridBagLayout gridbag = new GridBagLayout();
            GridBagConstraints c = new GridBagConstraints();
            getContentPane().setLayout(gridbag);
            c.gridx = 0;
            c.gridy = 0;
            c.gridwidth = 1;
            gridbag.setConstraints(myPlot, c);
            getContentPane().add(myPlot);
            show();
        }
public void putTicks(double time, int num)
{
      myPlot.addPoint(1, time, num, !first);
      first = false;
      myPlot.fillPlot();
```

```
        }
public void clearData()
{
      myPlot.clear(true);
      myPlot.fillPlot();
        }
}
```

You should reference your RMI programming documentation for details on how to compile and start the server code as well as the RMI registry on a server computer. “Displaying Plots Remotely” on page 180 has examples on starting the RMI registry.

Once you have started the RMI registry and the SPServerDemoServer program, you can run the demonstration model RemoteCall.spm to demonstrate this capability. (Chapter 5 of the *SIMPROCESS Getting Started Manual* has instructions on running this example.) When you start the simulation, the server program will put up a plot window and plot the values (SimTime and Number Accepted in this example) on the plot window. The window will appear as follows on the server:



If the server is not running, your simulation will be stopped and you will receive a message dialog stating that the server connection could not be made - similar to the following:

Expression Error
Object [Generate1] Error trying to invoke a remote method call. URLName = rmi://localhost/ Object name = serverdemo Method name = clearData
System Exception message = java.rmi.ConnectException: Connection refused to host: localhost; nested exception is:
java.net.ConnectException: Connection refused: connect
OK

If your parameters don't match in number and type, RMI Exceptions will occur and a message dialog will be presented with the error. You will notice in this example that the putPlotData method expects a Java double parameter and an int parameter. The following is a mapping of the SIMPROCESS data types that are allowed on the RemoteCall parameters and how they map to Java data types:

SIMPROCESS	Java
REAL	double
STRING	String
INTEGER	int
BOOLEAN	boolean

Method ExternalCall:

ExternalCall is a plug-in capability that can be licensed separately from CACI to allow users to make calls to external Java classes from within the expression scripts of a SIMPROCESS model. The classes to be called should be in the **`ext`** directory directly, in a package structure in the **`ext`** directory, or in a properly constructed jar file in the **`jre/lib/ext`** directory. Since ExternalCall is a function, a value will be returned. If the method called in the external class does not return a value (return type is void), SIMPROCESS will return the value TRUE; thus, the method should be assigned to a BOOLEAN local variable or attribute. Only valid SIMPROCESS data types can be returned (STRING, BOOLEAN, INTEGER, REAL). (See previous table in RemoteCall section for comparable Java data types.) Any other type returned will cause a run time error.

Method names should be unique. That is, SIMPROCESS looks for the appropriate method by name only. The number of parameters is not considered. Also, when getting a reference to the requested class, SIMPROCESS will only use constructors with no parameters.

The ExternalCall function requires two parameters: class name and method name. Other parameters after the first two are considered to be parameters for the method being called.

Some examples:

```
STRING : MyString;

MyString := ExternalCall("MyClass", "getString");
```

This example returns a string value. The "getString" method has no parameters.

```
REAL : number;

number := ExternalCall("MyClass", "getSquare", 100.0);
```

This example returns a REAL (double) value. The "getSquareRoot" method has one parameter (double).

```
BOOLEAN : boolval;

boolval := ExternalCall("com.acme.stuff.MyClass",
   "returnNothing");
```

This example shows a class that is within a package. The class name must include the package if the class file is within a package structure in the **ext** directory. (Note that jar files are not supported. The class files must be in a directory structure.) Also, the method does not return a value (return type is void), so the function must be assigned to a BOOLEAN variable. If multiple expressions have ExternalCall methods that reference the same class, each expression will create its own instance of the class. However, if the class is static, all expressions will share the same instance.

There is a sample class in the **SampleFiles** directory called **ExternalHello.java** that can be used to try out the ExternalCall system method. Simply copy the file to the **ext** directory and compile (**javac ExternalHello.java**). (In order to compile you must have a Java 2 Software Development Kit (J2SDK) installed.) In a model, you can call any of the methods to test ExternalCall.

```
stringvar := ExternalCall("ExternalHello", "getHello");
```

Method ActivateGenerate:

ActivateGenerate starts the generation of Entities by a Generate Activity. For this method to work correctly, the Generate Activity must not be active. This is accomplished by setting the start date (**Start/End** tab) to a date that is past the end date of the simulation. For instance, if the simulation is scheduled to end on 1/1/2005, then the start date of the Generate Activity must be 1/1/2005 or later. Note that this is the start date of the Generate Activity, not the start date of a particular schedule within the Generate Activity. When the appropriate conditions are met in the simulation for the Generate Activity to start, issue the command along with the name of the Generate Activity. It is important that the name of the Generate Activity be unique.

```
ActivateGenerate("Generate2");
```

SIMPROCESS Color Table

0	Black (Default)	33	SandyBrown
1	White	34	Gold
2	Red	35	Goldenrod
3	Green	36	LightGrey
4	Blue	37	MediumGoldenrod
5	Yellow	38	DarkOliveGreen
6	Cyan	39	ForestGreen
7	Magenta	40	LimeGreen
8	DarkGrey	41	MediumForestGreen
9	Grey	42	MediumSpringGreen
10	DarkRed	43	PaleGreen
11	DarkGreen	44	SeaGreen
12	DarkBlue	45	YellowGreen
13	DarkYellow	46	DarkSlateGrey
14	DarkCyan	47	DimGrey
15	DarkMagenta	48	Khaki
16	Aquamarine	49	Maroon
17	MediumAquamarine	50	Orange
18	CadetBlue	51	Orchid
19	CornflowerBlue	52	DarkOrchid
20	DarkSlateBlue	53	Pink
21	LightBlue	54	Plum
22	LightSteelBlue	55	IndianRed
23	MediumBlue	56	OrangeRed
24	MediumSlateBlue	57	VioletRed
25	MidnightBlue	58	Sienna
26	NavyBlue	59	Tan
27	SkyBlue	60	Turquoise
28	SlateBlue	61	DarkTurquoise
29	SteelBlue	62	Violet
30	Coral	63	Wheat
31	Firebrick	64	GreenYellow
32	Brown		

APPENDIX G

External Event Files

The Generate activity offers a File schedule. This appendix describes the format for the event file associated with the File schedule.

General Rules for Event Files

External event files define entity generation events. If event files are referred to in a Generate activity, SIMPROCESS reads the file at the beginning of a simulation run and schedules the generation of Entities as defined in the file.

Each record (line) in an event file must adhere to certain syntax rules, which are defined in the following section. Records must also adhere to these general rules:

- Each record in the file defines one generation event. There is no way to continue a record on the following line.
- The keywords (ENTITY, QUANTITY, etc.) followed by a colon (:) or equals sign (=) must not have any spaces between the colon or the equals sign and must not have any spaces between the colon or equals sign and the value associated with the keyword.
- The keywords and values are case sensitive.
- Records must be ordered by entity create time. SIMPROCESS will not generate entities for any event record whose entity create time is earlier than that of the previously processed event. For example, in the following sequence of creation dates:

    1. 01/02/2005
    2. 01/04/2005
    3. 09/11/2004
    4. 10/30/2004
    5. 01/12/2005

Records 1 and 2 are processed. Record 3 is bypassed, because its creation date is earlier than that of record 2. Record 4 is also bypassed, because its date is earlier than that of record 2, the last record for which entities were generated.

- Entity create time must be the first field in the event record. The remaining keyword parameters may be entered in any order.
- The entity type you specify in an event record must be defined to the model before it can be generated.

However, you can refer to a new type in the event file and select the **Selected in the list** option in the **External File Schedule** dialog. SIMPROCESS will automatically add it to the model.

- Any literal values with imbedded blanks must be enclosed in quotation marks (" ") when included in event records.
- Real numbers must include a decimal point.

- Records beginning with an asterisk (*) are considered comments and are ignored by SIMPROCESS.

Event Record Description

In the following syntax diagram:

- Items in **BOLD** face must be entered exactly as shown.
- Items in *italic* face represent variables for which you must substitute a value.
- Items enclosed in brackets ([]) are optional.

Syntax

[+]*time* [**QUANTITY:***value*] [**ENTITY:** *type*] [**ATTR:** *name*=*value*...]

Parameters

+

Indicates that the ensuing value is to be added to the time of the last event processed.

time

The time at which entities are to be created for this event record. Specify either a specific date and time or a relative value. Use the following format for a specific date and time:

mm/*dd*/*yyyy hh:mm:ss*

Where, for example, January 15, 2007, at noon is represented as:

01/15/2007 12:00:00

You can enter either real numbers or integers to indicate relative values: real numbers are assumed to refer to hours, while integers refer to days. Forty-eight hours after the start of simulation is shown as:

48.0

Which is the same as two days after the start of the simulation:

2

Forty-eight hours after the previous entity generation event:

`+48.0` **or** `+48:00` **or** `+2`

Notes on specifying event time:

- You can omit seconds when specifying the time. SIMPROCESS assumes a zero for the omitted parameter.
- Do not specify a time in *hh:mm* without a date, unless you precede it with a plus sign (+). Although SIMPROCESS will accept this value, its interpretation is unpredictable. For example, acceptable formats are:

  `48.0` 48 hours after the start of simulation

  `+48:00` 48 hours after previous generation event

- SIMPROCESS will accept a 2-digit value for the year, It assumes that values over 49 refer to years in the 20th century, and values under 50 refer to the 21st century.

QUANTITY:value

The number of entities to generate at the entity generation event. Enter a number in place of *value*.

If QUANTITY is omitted, SIMPROCESS uses the default **Quantity** value in the **Generate Activity Properties** dialog.

ENTITY: type

The type of entity to generate.

For *Type*, enter an entity type name. If the name includes blanks, enclose the entire string in quotes.

If ENTITY is not specified, SIMPROCESS uses the default Entity value in the **Generate Activity Properties** dialog.

ATTR: name=value...

Assigns values to globally defined attributes for entity instances.

You can assign values to any number of attributes in the VARS argument.

The *value* you specify must be consistent with the data type defined for the attribute.

Note that if you specify an attribute name that has not been defined in your model, you can select the **Selected in the list** option in the **External File Schedule** dialog. SIMPROCESS will add it to the model.

If a record contains any syntax error or undefined model element (without using **Selected in the list** option), the entire event record is considered invalid and is bypassed.

Examples

1. Generate `GreenDot` entities at 3 a.m. on January 1, 2005. Generate the number of entities defined in the **Generate Activity Properties** dialog.

```
01/01/2005 03:00:00 ENTITY:GreenDot
```

2. Generate six `RedDot` entities 7 hours after the simulation begins.

```
7.0 QUANTITY:6 ENTITY:RedDot
```

3. Generate four `RedDot` entities 7 hours after the previous entity generation.

```
+7:00 QUANTITY:4 ENTITY:RedDot
```

4. Generate a Truck entity at 2 a.m. on January 3, 2005. Assign a value of 50,000 to user attribute *Weight*, and the string "Yo, Heavy" to user attribute *Tag*:

```
01/03/2005 2:00 ENTITY:Truck ATTR:Weight=50000 Tag="Yo, Heavy"
```

5. Generate more Truck entities 4 hours after the previous event. Generate the number of entities defined in the `Generate Activity Properties` dialog:

```
+4.0 ENTITY:Truck
```

6. Generate two `RedDot` entities at 4 a.m. on January 3, 2005:

```
01/03/2005 04:00:00 ENTITY:RedDot QUANTITY:2
```

Notes on the Examples

If the examples are processed during a simulation which begins at midnight, January 1, 2005, the events occur at the following times:

1. January 1, 2005, 3:00 a.m.
2. January 1, 2005, 7:00 a.m.
3. January 1, 2005, 2:00 p.m. (14:00)
4. January 3, 2005, 2:00 a.m.
5. January 3, 2005, 6:00 a.m.
6. Never. The specified time is earlier than the time of the previous event, so the record is discarded.

APPENDIX H

Simulation Results File

The Simulation Results file is generated from the **File** menu. Select **File/Export/Simulation Results** to open the **Save Statistics** dialog. The Simulation Results file will, by default have a `.xpt` file extension and be saved to the current model directory. This file is tab-delimited, and can be opened using a text editor or spreadsheet.

The file will contain the complete statistical measures corresponding to the reports selected for the current model. This file give you raw statistical data that is displayed in the Standard and Custom Reports, in a standard format that can be opened by many different applications.

Format of the Simulation Results File

Each line of the exported simulation results file is a statistic recorded for objects such as Entity Types, Activities, or Resources. Each record contains the following fields or columns:

Owner Type

This is the type of the object that owns this statistic record. The four types are:

- **Entity**: representing an Entity Type
- **Activity**: representing an Activity
- **Resource**: representing a Resource
- **TimeStamp**: representing a Time Stamp
- **Attribute**: representing an Attribute

Owner Name

This is the full hierarchical name of the specific object that owns this statistic record.

Name

This is the name of the specific object that owns this statistic record.

Stat Type

This is the type of statistic displayed. Contained in the third column from the left, the Stat Type is an abbreviation for the name of the performance measure whose parameters follow to the right. See “Statistic Types,” beginning on page 507 for a complete description of the types of statistics.

Replication

This number is the replication that the statistic was collected from. Any number, 1 or greater, refers to a specific replication.

If the replication number is 0, the statistics are sum of all replications. An -1 means that this statistic is the average of all replications.

Minimum

This is the smallest value that has been recorded for this statistic.

Maximum

This is the largest value that has been recorded for this statistic.

Sum

It is the total of all observed values for the statistic (i.e. X_i), if this is observation based.

For time weighted, it is the total of each observed value multiplied by the time that this value has persisted in (i.e. $X_i * \Delta T$).

Sum of Squares

It is the summation of the square of each observed values (i.e. $\sum(X_i^2)$), if this is observation based.

For time weighted, it is the summation of the square of each observed value multiplied by the time that this value has persisted in (i.e. $\sum(X_i*\Delta T)^2$).

Count

This is the number of observations recorded when the statistic was collected.

Average

This is the average of the statistic.

Std Deviation

This is the standard deviation of the statistic.

Statistic Types

The table below gives the descriptions of the statistic types within SIMPROCESS.

Labels	Type of Statistics	Descriptions
Entities:		
`tokendelay`	Observation based	Total cycle time (i.e. sum of wait, hold, and process)
`tokenwaitdelay`	Observation based	Time waiting for available resource
`tokenholddelay`	Observation based	Time waiting for condition to be reached
`tokenprocessdelay`	Observation based	Time processing (i.e. at specified duration)
`tokenlevel`	Time-weighted	Number of entities in system
`tokenwaitlevel`	Time-weighted	Number of entities waiting for available resource
`tokenholdlevel`	Time-weighted	Number of entities waiting for condition to be reached
`tokenprocesslevel`	Time-weighted	Number of entities in process (i.e. at duration)
`tokentotalborn`	Only the last value is recorded	Number of entities being generated

Labels	Type of Statistics	Descriptions
tokentotalalive	Only the last value is recorded	Number of entities still residing in the system
tokentotalkilled	Only the last value is recorded	Number of entities destroyed
UDV.delay	Observation based	Statistic of the specified attribute
UDV.level	Time-weighted	Statistic of the specified attribute
Resources:		
resrccap	Time-weighted	Units of resources (i.e. capacity)
resrcidle	Time-weighted	Units of idle resources
resrcbusy	Time-weighted	Units of busy resources
resrcmaintenance	Time-weighted	Units of resources not available (Unplanned Downtime)
resrcdown	Time-weighted	Units of resources not available (Planned Downtime)
resrcreserved	Time-weighted	Units of reserved resources
byactivitybusy.level	Time-weighted	Units of busy resources at the specified activity
Activities:		
tokentotalin	Only the last value is recorded	Number of entities entered this activity

Labels	Type of Statistics	Descriptions
tokentotalhere	Only the last value is recorded	Number of entities still residing in this activity
tokentotalout	Only the last value is recorded	Number of entities that have left this activity
tokentotalearlyout	Only the last value is recorded	Number of entities that left the activity without processing
bytokenin	Only the last value is recorded	Number of entities of the specified type that entered the activity
bytokenhere	Only the last value is recorded	Number of entities of the specified type still residing in the activity
bytokenout	Only the last value is recorded	Number of entities of the specified type that have left the activity
bytokenoutearly	Only the last value is recorded	Number of entities of the specified type that left the activity without processing
tokendelay	Observation based	Total cycle time (i.e. sum of wait, hold, and process) at this activity
tokenwaitdelay	Observation based	Time waiting for available resource at this activity
tokenholddelay	Observation based	Time waiting for condition to be reached at this activity

Labels	Type of Statistics	Descriptions
tokenprocessdelay	Observation based	Time processing entities (i.e. in the specified durations) at this activity
bytoken.delay	Observation based	Total cycle time (i.e. sum of wait, hold, and process) for the specified entity type at this activity
bytokenwait.delay	Observation based	Time waiting for available resource for the specified entity type at this activity
bytokenhold.delay	Observation based	Time waiting for condition to be reached for the specified entity type at this activity
bytokenprocess.delay	Observation based	Time processing entities (i.e. in the specified durations) for the specified entity type at this activity
tokenlevel	Time-weighted	Number of entities at this activity
tokenwaitlevel	Time-weighted	Number of entities waiting for available resource at this activity
tokenholdlevel	Time-weighted	Number of entities waiting for condition to be reached at this activity
tokenprocesslevel	Time-weighted	Number of entities in process (i.e.at duration) at this activity
bytoken.level	Time-weighted	Number of entities of the specified type at this activity

Labels	Type of Statistics	Descriptions
bytokenwait.level	Time-weighted	Number of entities of the specified type waiting for available resource at this activity
bytokenhold.level	Time-weighted	Number of entities of specified type waiting for condition to be reached at this activity
bytokenprocess.level	Time-weighted	Number of entities of the specified type in process (i.e.at duration) at this activity
UDV.delay	Observation based	Statistic of the specified attribute
UDV.level	Time-weighted	Statistic of the specified attribute
Time Stamps:		
tokendelay	Observation based	Time elapsed between Time Stamps

APPENDIX I

UML Interfaces

SIMPROCESS and Universal Modeling Language (UML) tools complement each other by bridging the gap from business analysis to systems analysis. SIMPROCESS is used for the business process models, and UML tools are used for the systems models. These tools work together in documenting the operational architecture of a business. They communicate the content of the business requirements and the systems requirements and designs by using both notations in combination.

UML-based tools such as Rational Rose focus on Systems Modeling to help define requirements, model designs, and develop object-oriented code such as Java. Rational Rose is one of the leading tools on the market for system modeling activities in a software development life cycle, but other capable tools support the UML standard.

UML tools do not fully address the functional/business process modeling requirements. For example, Use Cases and Activity Diagrams are the only views UML has for modeling any part of the business process, but they still focus on the "system" needs in the models rather than the function or business steps. For instance, Use Cases show Actors (usually people) interacting with objects (usually realized as object oriented components such as Java classes). This helps to understand the system transactions but does not model the full breadth of the business workflow or process. Activity diagrams similarly model activity steps that can be used to model business flow diagrams but typically focus on objects and transition of states between objects based on changes to the objects in a system transaction. Activity diagrams do not provide the dimensions needed to do robust business process analysis such as dynamic modeling, entity flow simulations, resource utilization, queueing theory, and cost based business metrics.

SIMPROCESS focuses on the functional and business work flow (including manual/physical processes that have nothing to do with the system but need to be understood and modeled in order to build a system to support the business properly) and not just on the system transactions. This is made clear when looking at how activities such as delays, splits, joins, batching, unbatching, assembling, etc., are described for behavior in a SIMPROCESS model. These are representative of business activities that people do in carrying out their jobs regardless of what interaction they have with the system. In addition, SIMPROCESS looks at the resources, entities, and workflow as a complete dynamic model that allows visualization of how the business works both from manual steps and system interaction. This is important in order to match up the business transactions with the system transactions.

SIMPROCESS has a more functional and business view and focuses on activity based costing metrics, throughput, bottlenecks, timing, re-work and other business performance metrics regardless of the system that is supporting the business. This is why business and functional representatives prefer SIMPROCESS for the business modeling - it speaks their language. SIMPROCESS focuses on the business concerns and not all the system modeling notations and methods (which often confuses functional people). The dynamic modeling capabilities for business metrics are non-existent in UML modeling tools. This is appropriate since UML tools are system analysis, design, and development tools, not process and workflow modeling tools.

There is a clear gap between business analysis and systems analysis. SIMPROCESS focuses on the business analysis and UML tools focus on the systems analysis. Clearly, both are needed from business requirements to systems requirements to system design to system development. They work hand in hand and not in opposition to each other. This gap in business analysis and systems analysis is the basis for the SIMPROCESS to UML interfaces. These interfaces use the complementary strengths of both UML and SIMPROCESS to provide customers a complete toolset for business and systems modeling.

SIMPROCESS has two basic interfaces to UML. One is the ability to export a SIMPROCESS model to a UML Activity Diagram. The export to Activity Diagrams is based on the standard UML XMI specification and provides a transfer of the SIMPROCESS activities and connections to UML activities and transitions. In addition, SIMPROCESS Entities and Resources are exported as UML Classes (with attributes included); however, the classes are not accompanied by a UML Class Diagram. The Activity Diagram includes the Diagram information for Rational Rose only. The XMI activity information can be imported into any UML tool other than Rational Rose that supports XMI by simply deleting the Diagram information at the bottom of the XMI file that is created from the export process.

The other type of interface is an active link between activity nodes on a SIMPROCESS model and Use Case Diagrams in a Rational Rose model. This interface requires a Microsoft Windows version of SIMPROCESS and a licensed copy of Rational Rose.

Each type of interface is described in more detail in the following sections.

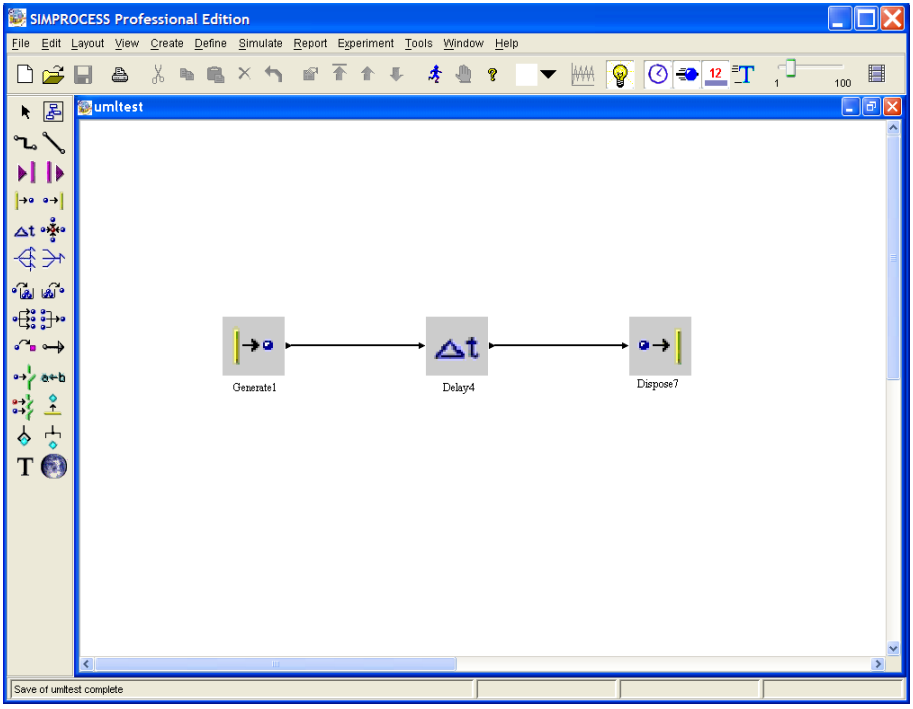
Exporting to UML

This capability can be used by selecting **File/Export/UML Activity Model** from the SIMPROCESS menus. It outputs the model to a UML compatible XML file. No dialog is displayed for this export operation. The file is created in the model's directory with a `.xml` extension and is compatible with Rational Rose, including diagram information. The XMI file may be compatible with other UML tools as well, such as the ArgoUML open source tool, but diagram information intended for Rational Rose will not be compatible with other UML tools.

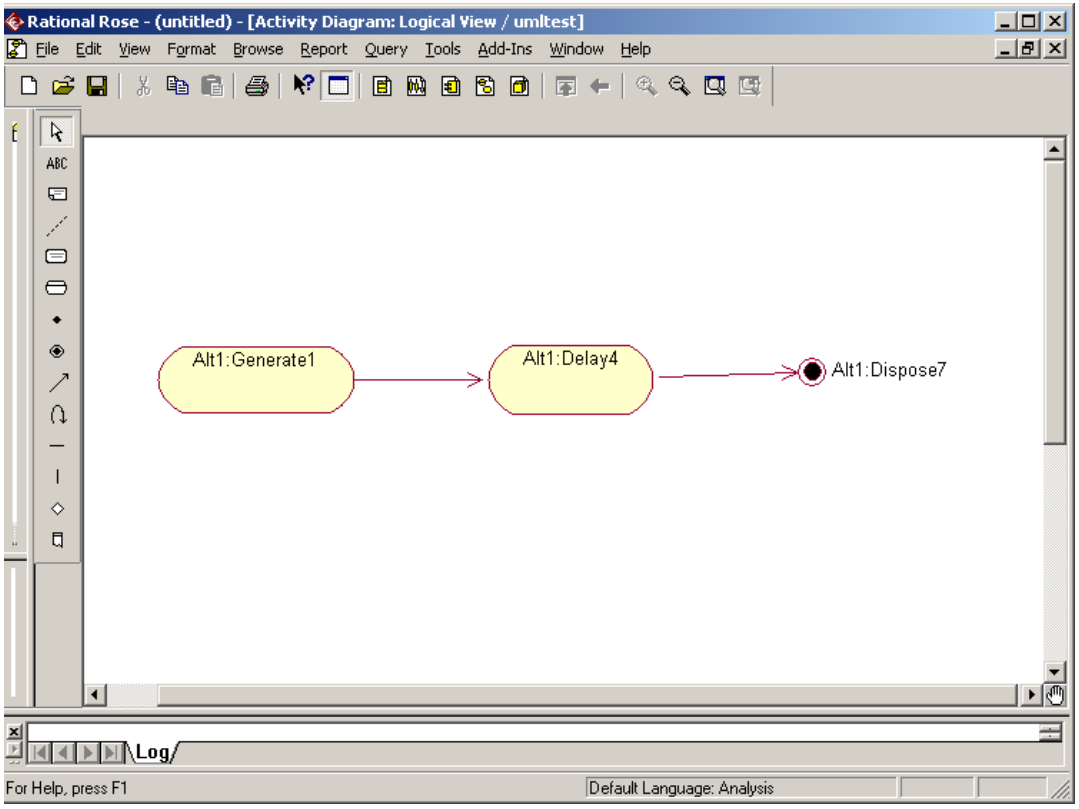
To import the model into Rational Rose, Rational Rose must have the Import/Export XMI plug-in installed. This plug-in can be obtained from the Rational Rose web site (www.rational.com). Once it is installed, simply choose the **Import UML Model** from the **Tools** menu in Rational Rose.

In some cases, due to slight differences in the aspect ratio of the graphics in SIMPROCESS and the Rational Rose tools, minor visual clean up of the imported Activity Diagram may be required.

The following is a simple SIMPROCESS model that is exported to UML:



The above SIMPROCESS model would look like the following in Rational Rose:

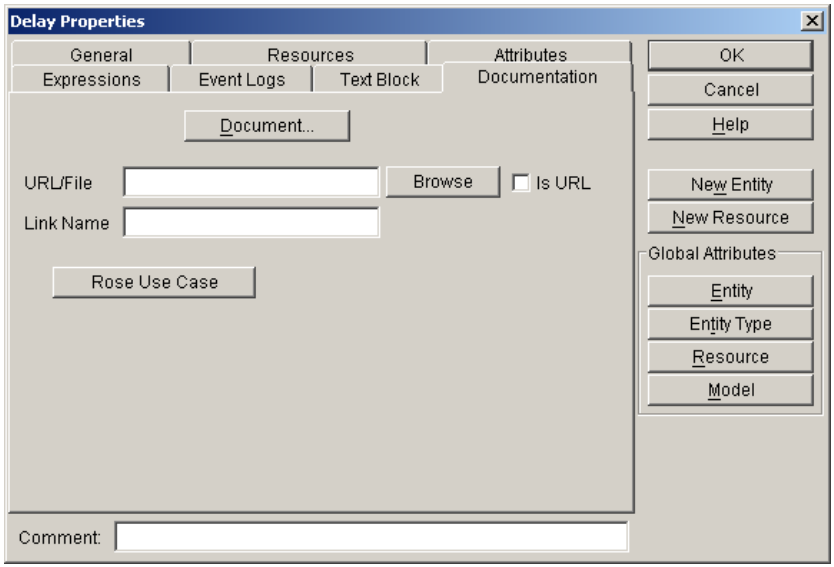

Rational Rose - (untitled) - [Activity Diagram: Logical View / umltest]
File Edit View Format Browse Report Query Tools Add-Ins Window Help
ABC
Alt1:Generate1
Alt1:Delay4
Alt1:Dispose7
Log
For Help, press F1
Default Language: Analysis

Rose Use Cases

SIMPROCESS provides the capability for the user to connect nodes (activities) on the SIMPROCESS model directly to a Rose Use Case Diagram. This allows for a seamless flow from business process modeling and simulation analysis in SIMPROCESS to systems models in Rose. Exported HTML views of the SIMPROCESS models (page 20) are directly linked to Rational Rose exported HTML models. This gives stakeholders a seamless wide area review of the business process models with Rose Use Case models. SIMPROCESS models typically include both manual process steps (activities) and steps that are automated with information technology. This capability ties the manual process steps and the automated process steps (supported by Use Case links) together so that the system requirements are in complete context with the business process.

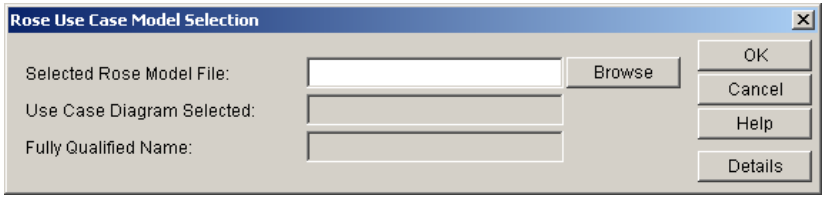
This feature is licensed by CACI separately from SIMPROCESS and is only available with the Windows version of SIMPROCESS. For this feature to be active, the additional license must be purchased, and Rational Rose must be installed.

Rose Use Case links are added by selecting the **Rose Use Case** button on the **Documentation** tab on any activity properties dialog. This button will only be enabled if the above criteria are met.



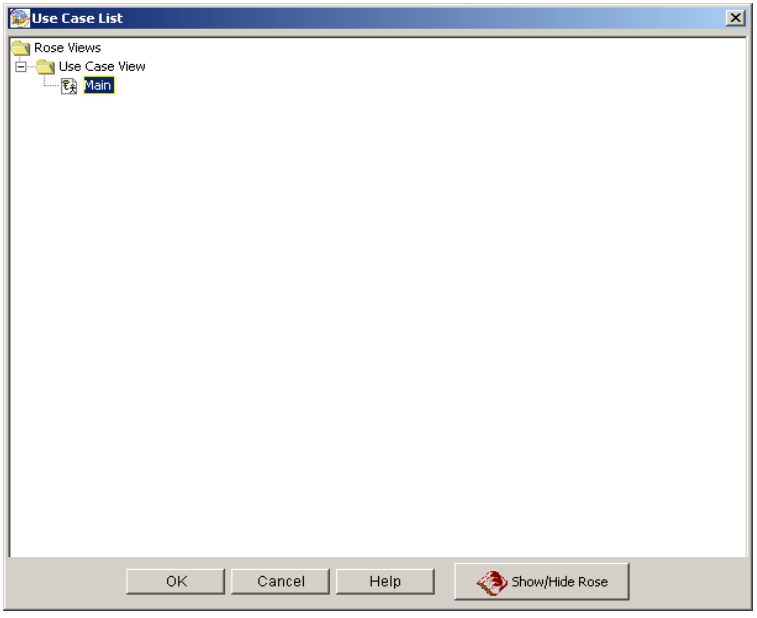
Clicking **Rose Use Case** brings up the following dialog. The path to a Rose model file can be entered or the **Browse** button can be used to select a Rose model file. Once a Rose model has been selected, a reference to it is stored in the SIMPROCESS model file for subsequent use (this reference will be invalidated if the file is later moved or renamed). The connection to a Rose model remains until the

model file name is cleared, and the **OK** button is clicked.



Once a Rose model is connected to the SIMPROCESS model, the **Details** button will connect SIMPROCESS to a licensed copy of Rational Rose using the Rational Rose Automation capability. If a successful connection and load of the Rose model is completed (this occurs in the background), a window like the one shown below is presented listing all the Rose views and subordinate packages that contain Use Case Diagrams. Note that if a package or view does not contain any Use Case Diagrams, it is not included in the window since the SIMPROCESS connection is to Use Case Diagrams only.

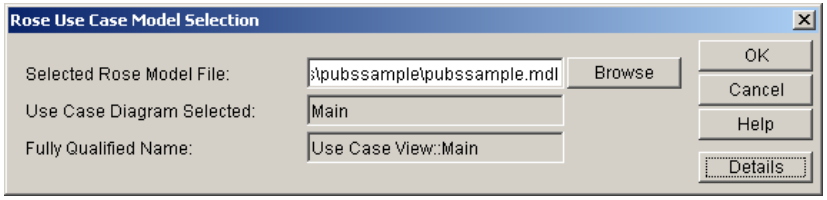
Utilizing this window, a Use Case Diagram can be navigated to and selected to associate with the SIMPROCESS activity node. Note that the structure in the dialog is a simple Tree structure that works like other graphical file directory trees.



A single Use Case Diagram can be selected by clicking on it and then clicking the **OK** button. This

action will assign that Use Case Diagram to the SIMPROCESS activity node. Optionally, the **Show/Hide Rose** button can be selected to bring the Rose tool and model up on the screen so that it is available. Once Rose is visible the Rose model can be modified as desired, and the Rose model can be saved. However, any new Use Case Diagrams added will not automatically appear in the SIMPROCESS Use Case List window until it is closed and reopened.

After a Use Case Diagram is selected and the **OK** button is clicked, the Use Case Diagram information will be added into the SIMPROCESS dialog, as shown below. The Use Case Diagram name and fully qualified name (which includes the entire package structure in Rose) are not directly editable. To clear the Use Case Diagram connection, simply select and clear the **Selected Rose Model File** field in this dialog and click **OK**. To change the **Use Case Diagram Selected** (the node to which SIMPROCESS is connected), simply click on the **Details** button and choose another Rose Use Case Diagram from the Use Case Diagram dialog as described above.



An important feature of this Use Case Diagram connection between SIMPROCESS and Rational Rose is that when the Rose model is published to HTML and the SIMPROCESS model is published to HTML, the SIMPROCESS HTML nodes will be automatically linked to the Rose Use Case Diagrams in the HTML. For this feature to work, the Rose published model must be in a directory named `rose` within the directory of the SIMPROCESS published model on the disk drive or web server. When navigating the SIMPROCESS published HTML model, moving the mouse pointer over a SIMPROCESS activity node that has been connected to a Rose Use Case Diagram as described in this section gets a Javascript popup that links directly to the Rose published HTML Use Case Diagram automatically. This capability is very useful for wide area review of business process models that have Use Case functional requirements attached to certain nodes in the SIMPROCESS model. Hence, the business process requirements and the system requirements are in context of each other using this technique.

APPENDIX J

Running Models Without GUI

SIMPROCESS models can be run without the SIMPROCESS Graphical User Interface (GUI). There are two executables in the SIMPROCESS directory: SIMPROCESS and SPRunSimulation (any extensions are platform specific). The SIMPROCESS program starts the SIMPROCESS GUI, required to build and edit models. This GUI is typically used to run models as well. However, SPRunSimulation can be used to run a SIMPROCESS model without the GUI. A valid `license.dat` file is required to run SIMPROCESS and SPRunSimulation. The same license file is used for both.

Since access to the GUI is not available, results of the run must be automatically output to the SIMPROCESS database (see page 322), user created files, or a user created database. Statistics collected during the run can be accessed using System Methods. (See "Accessing Statistics During Simulation" on page 267.) The Standard Report can be generated automatically after the run by selecting **Generate Standard Report after run** on the **Statistics Collection** dialog. (See "Generating Standard Reports From Experiments" on page 347.)

To run a model with SPRunSimulation, either execute commands from a command prompt or create a batch file or a shell script. The command must include SPRunSimulation and the complete path to the model that is to be run, as shown in this example for Windows.

```
SPRunSimulation "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing.spm"
```

The above is the simplest form for running a model without the GUI. However, model parameters (see page 216) and process alternatives can be set as well as the number of replications. In addition, the simulation results can be automatically placed in the SIMPROCESS database, and the model can be

saved. These options can be set either on the command line or by using a properties file.

Available Options

The following options can be set on the command line or in a properties file. The format of the option is always the name of the option followed with no spaces by an equals sign followed with no spaces by the value.

- Any global attribute designated as a model parameter - Model.NumResource1=2
- Any process alternative - "Process name=Alternative name"
- Number of replications - Replications=5
- Design for committing the results to the SIMPROCESS database - "Design=My Design"
- Scenario for committing the results to the SIMPROCESS database (must be used if Design is used) - "Scenario=My Scenario"
- Option to save the model after the parameters are set (thus, the next time the model is opened in SIMPROCESS, the model parameters set by command line or properties file retain their latest value) - Save=True (the absence of this option is equivalent to Save=False)

Setting Options on Command Line

Any parameters to be set must follow the model on the command line. For example

```
SPRunSimulation "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing.spm"
Model.NumProdAPersonnel=6 Model.NumProdBPersonnel=4
"Purchasing=Centralized, Functional" Replications=2 "Design=2 Reps"
"Scenario=Scenario 1" Save=True
```

Parameters that have spaces must be in quotes. The order of the parameters following the model is not important. If Design and Scenario are omitted, then the results are not committed to the database.

Setting Options Using Properties File

The preferred method for setting parameters is to use a properties file. The file can have any name as long as the extension is `.properties`. When using a properties file, the properties file name follows the model on the command line.

```
SPRunSimulation "C:\Program
```

```
Files\SIMPROCESS\models\Demos\Purchasing.spm" "C:\Program
Files\SIMPROCESS\models\Demos\Purchasing\Purchasing.properties"
```

This example shows a file named `Purchasing.properties` that is in the directory of the **Purchasing.spm** model. The following is an example of a properties file. Three model parameters are set, one process alternative is set (Purchasing), the number of replications is set, and the Design and Scenario are set. The order is not important. Do not include a Design and Scenario if the results of the run should not be committed to the SIMPROCESS database.

```
Model.NumProdAPersonnel=6
Model.NumProdBPersonnel=4
Model.NumProdCPersonnel=4
Purchasing=Centralized, Functional
Scenario=s1
Design=New Design
Replications=2
```

Index

A

activities
  Activity Browser 27
  aligning 38
  Assemble 96–98
  Assign 107–108, 222
  Batch 98–100
    See also Batch Activity
  Batch, system attributes of 214
  Branch 110–111
  Clone ??–117, 117–118
  Comment (dialog field) 60
  commenting 60
  connecting 55
  creating from menu 42
  defining resource requirements 131
  definition of 18, 53, 54
  delay time, defining 59, 66–68
  displaying name under icon 59
  distributing 39
  Document command 60
  documenting 60
  entity processing time 59
  Free Resource 135–136
  Gate 101–104
    entity release policies 101
    gating policies 101
  Generate 276–293
  Get Resource 133–134
  grouping 40
  Hide 41
  Hide All Names 41
  icons, choosing 60
  icons, labeling 60
  icons, showing name under 59
  icons, types 60
  interrupting 301
  Join 118, 122–125
  linking 55
  Local Attributes 221
  Merge 114
  Name field 59
  Properties dialog 58–62
  removing from model 58
  Replenish Resource 137–138
  resources needed by, defining 59
  Show All 41
  Show All Names 41
  Show Attached 41
  Show Local Names 41
  Split 118, 119–122
  Synchronize 104–106
  Text Block 61
  time required to perform 66
  Transfer 114–??
  Transform 108–110
  Unbatch 100–101
  ungrouping 40
  using activity attributes in an expression 233
  variable resource usage 131
Activity Properties dialog fields 58–62
Activity-Based Costing 153–160
  Cost Calculations 159
  Cost Periods 156
  Resource Costs 157–159
adding objects to a model 57–58
animation
  changing during simulation 81
  settings 81
Animation Settings 47, 79
  Animation Speed 47, 79
  Show Clock 47, 79
  Show Counts 47, 79
  Show Entities 47, 79
  Update Dynamic Labels 47, 79
Assemble Activity 96–98
  batch component entities 98
Assemble component entities pad 96
Assign Activity 107–108, 222
  Entity Priority 108
  User Defined Attributes 107
Attribute Value Initialization 241

Attributes 212
  Model Parameter 218
  Model Paramters 80
  System 214
  User Defined 215
Automatic saving 26

B

Background Color 38
Background Graphics 145
Background Text 141
Batch Activity 98–100
  Batched Entity 99, 103
  Maximum Batch Size 99
  maximum number of entities 99
  Maximum Wait Time 100
  Minimum Batch Size 100
  parent entity 99, 103
Batched Entity, of Batch activity 99, 103
Both must be reached, Generate schedule field 278
bottlenecks
  sources of 55
Branch Activity 110–111
Branch Connectors 111

C

calendar dates
  effect on simulation 78
calendar event. *See* events, calendar
calendar schedule 278
changing entity type 108
Clone Activity ??–117, 117–118
  copy time stamps 118
  number of copies 118
Comment field 58, 60
Commit to Database 323
Confidence Intervals 82, 163
Connectors
  Hide All Names 42
  Show All Names 42
  Show Local Names 42
connectors
  Auto Label 112
  Branch Activities and 110
  changing attributes 112
  defined 55
  names, displaying 112
  Properties dialog box 112
converting entities from one type to another 108
Count Limit, of entity release 278
Create Menu 42–43
  Activities 42
  Background Graphic 43
  Background Text 43
  Processes 42
cycle time
  definition of 18
  Dispose activity and 69
  ending 69
  reports 168, 173
cyclical schedules 279–281
  defining 279–281
  See also sequence of events
  types 279

D

Database
  examples 265
  interfacing with 260–266
  setting up DSN 260
  system methods 262
database graphs 329
Database Queries 327
database reports 329
Date field in calendar events 283
Define Menu 43–45
  Attributes 45
  Distributions 44
  Entities 43
  Functions 45
  Model Description 45
  Resource Downtimes 44
  Resources 43

Seeds 45
Templates 45
Time Stamps 45
Delay Activity 66, 66–68
Delay Duration
for Assemble activities 98
for Unbatch activities 101
Delay Time field 66
delay time, specifying 66–68
deleting objects 58
Display Error Alerts 345
Display Error Alerts Field 336
Displaying ABC Reports 161
Dispose Activity 69
Distribution
Beta 432
Erlang 433
Exponential 430
Gamma 431
Geometric 439
Hyperbolic 440
Lognormal 435
Normal 428
Poisson 436
Triangular 429
Uniform 427
Weibull 434
distributions
defining standard and tabular 44
viewing graphically 65
Document command
template for 60
Documentation
Model Description 45
printing 20–21
Downtimes
defining 44
Duplicate 22
Duration
for Assemble activities 98
Duration field 281
Dynamic Label 141

E

Edit
Activity Brower 27
Edit Menu 21–31
Clear 22
Copy 22
Cut 21
Duplicate 22
Model Search 28
Paste 22
Preferences 23
Properties 31
Resize 22
Select All 22
Undo 21
Entities
adding 70–72
assembling 96
branching on priority 111
branching on type of 111
changing type of (Transform Activity) 108
combining 96
coordinating release of 104
copying 72
cycle time 69
defined 54
defining 63, 70–72
deleting 72
destruction of 69, 100
disposal of 69, 100
duplicate (Clone Activity) 117
Generate activity and 63
icon, selecting 70, 71
input to Gate Activity 101
instance (defined) 70
parent entities 98, 99, 103
preempting lower priority 139
priority 71, 113
changing 108

in Assign Activity 108
of transformed entity 109
released by Gate Activity 102
removing 72
reports 165
Transform Activity and 108
type (defined) 70
using entity attributes in an expresssion 233
entities
cyclical generation 279
defining 43
generation 276
generation schedule in event file 284
none generated, reasons for 276
Recorder 311
Time Stamps vs. Recorder Objects 311
tracking arrival and departure times 311
Entities, accumulating 101
Entities, batching. *See* Batch Activity
Entities, limiting number in Dispose 69
entity count 166
Entity Related Activities 96
event cycles
Repeat Sequence 280
repeating 280
scheduling of 283–284
types 279–280
event files 284
all defined option 285
checking syntax of 285
entity types, selecting 285
identifying to SIMPROCESS 285
new entities specified in 286
Event Logs 309, 311
Recorders 311
Time Stamps 309
events
calendar 278–284
Date field 283
trigger point 283
changing sequence of 280
Count Limit 282
Duration 281
duration of 281
inactive periods 284
Move 280
moving 280
No event 284
number of times executed 281
Repeat Event 282
repeating 281
scheduling of 284
sequence of 280
single event 284
upwards option 280
Experiment Manager 334
Database Tables 335
Experiment Errors 345
Experiment Operation 344
Experiment Setup Form 335
Experiment Trace 344
Generating Standard Reports 347
Interacting With Experiments 346
Run All Experiments 342
Run Selected Experiments 342
Run Specific Experiment 342
Experiment Menu 50
Define Experiments 50
Run All Experiments 50
Run Selected Experiments 50
Run Specific Experiment 50
Experiments
Defining Experiments 335
Entering Design Information 337
Entering Experiment Information 335
Entering Model Information 336
Entering Model Parameter Information 339
Entering Process Alternative Information 340
Entering Scenario Information 338
Running Experiments 342
Starting Experiments 342
ExpertFit 50

Exporting
Activity List 20
Graphics Image File 20
Simulation Results 20
UML Activity Model 20
Expressions 213, 226–247
Language Basics 226
Using Attributes in 232
external data, using 284
external files 284

F

File Menu 19–21
Close 19
Exit 21
Export 20
Import 20
New 19
Open 19
Print 20
Save 19
Save As 19
file, input to Generate activity
See event files
Free Resource Activity 135–136
Functions
defining 45

G

Gate Activity 101–104
entity release policies 101
gating policies 101
Threshold Release 104
Trigger Release Quantity 104
used as a buffer 102
Generate Activity 57, 63–65, 276–293
active period of entity release 276
Both must be reached 278
calendar schedule, defining 278
complex, defining 276–293
Count Limit 278
cyclical schedule, defining 279–281
Daily schedule 278
Date schedule 278
Define Entity 63
defining 63–65
defining complex 276–293
entities generated 63–65, 277
entity release begin and end dates 276
events. *See* sequence of events
external event file 284
external schedule 286
Hourly schedule 278
inactive periods 284
Interval 64–65, 277
limiting number of entities generated 278
Monthly schedule item 278
periodic schedule, defining 277
Quantity 63
Release Begin 276
release dates and simulation dates 276
Release End 276
schedule
calendar 278
Daily 278
Date 278
defaults 277
file input 284
Hourly 278
number of entities at each release 277
Use default 277
Weekly 278
schedule items
adding 277
Both must be reached 278
copying 277
Count 277
Count Limit 278
defining 276–279
deleting 277
editing 277
entity categories 277
Interval 277

limiting number of entities 278
modifying 277
Monthly 278
periodic 277
removing 277
Yearly 278
Summary 293
time between entity generation events 64–65, 277
Weekly schdedule 278
Yearly schedule item 278
Get Resource Activity 133–134
gif 146
Global Attributes
defining 216
graphics
importing 146
grid
color 40
grid lines 40
snap to grid 40
spacing 40

H

Help Menu 52
help, getting
help topics 52
online help 62
hierarchical models 53–54
hierarchy, ascending 81
hierarchy, descending 80
historical data
See also event files
historical data, using 284
Hold pad, of Gate activity 101

I

Icon dialog field 60
Icon Manager 51
icons
activity icons 60
adding text to 60–61
entities, listing 71
labeling 60–61
showing object name under 59
Importing
Background 20
Icon 146
Version 2.2.1 Model 20
Importing graphics 146
Initializing attribute values 241
interval between entity generations 64
Interval dialog field 64

J

Java RMI 288
Join Activity 118, 122–125
jpeg 146
jpg 146

L

Launch Database Application 325, 331
Layout Menu 32–40
Align 38
Background Color 38
Bring To Front 40
Distribute 39
Distribute Pads 40
Grid Color 40
Grid Lines 40
Grid Spacing 40
Group 40
Send To Back 40
Snap To Grid 40
Swimlanes 33
Ungroup 40
Library
Concepts 198
Management 199
Library Manager 199
limiting entities in Dispose activity 69
Local Attributes
defining 221

M

Manage Results form 325, 331
Maximum Batch Size, of Batch activity 99
Maximum Entity Count, Dispose activity parameter 69
Maximum Wait Time, of Batch activity 100
Merge Activity 114
Minimum Batch Size, of Batch activity 100
model
  adding objects to 57–58
  checking for errors 80
  components 53–55
  hierarchical structure 53–54, 55
  removing objects from 58
  selecting objects in 58
  using Model Attributes in an expression 233
  Verify Model 80
  verifying 80
Model Attributes
  defined 215
  using in an expression 233
model design 324
Model Parameters 80, 218
Move command, events 280
moving down a level in hierarchy 80
moving up a level in hierarchy 81

N

Name (dialog field) 59
naming
  activities 59
no entities generated, reasons 276
No Event schedule 284

O

objects
  adding to draw space 57–58
  deleting 58
  removing from draw space 58
  selecting several 58
OptQuest for SIMPROCESS 349, 379
  Constraints 356
  Decision Variables 355
  Defining An Optimization 354
  Objective 354
  Preparing for Optimization 352
  Process Alternatives 362
  Run Options 362
  Running an Optimization 364
  Tips and Suggestions 371
Output Entity, Assemble activity 98

P

pads
  Assemble and Release (Assemble Activity) 96
  connecting levels in model hierarchy 75
  defined 55
  distributing 40
  Hide All Names 42
  Hold and Trigger pads (Gate Activity) 101
  input pads 104
  number of in Synchronize activity 104
  Show All Names 42
  Show Local Names 42
Palette bar
  contents 57
  using 57–58
parent entities 98, 99
parent entity 99, 103
PDF manuals 52
periodic schedule 277
png 146
Print
  Layout 20
  Model 20
  Model Documentation 20
  Process Documentation 20
priority
  of transformed entity 109
priority, of entities 71, 108
  branching on 111
probability
  branching on 111

Probability distributions 316
Process Modeling 13
processes
  and model hierarchy 53–54
  creating from menu 42
  defining 73
  definition of 18, 53
  sub-processes 74–76
    activating 75
    active 74, 75
    alternatives 74
    copying 75
    deleting 75
    modifying 75

Q

Queue
  Gate activity 102
  hold for condition 96
  wait for resource 55, 96

R

random distributions
  specifying 64–65
random number stream 65
rank method 97, 100, 103, 105
Real-Time Plots 166, 170, 173
  plot group 190
  saving 182
  Setting Plot Properties 178
  zooming 184
Recorder Objects
  output file (recorder.msg) 311
Recorders
  Definition of 311
Release Begin 276, 277
Release End 276, 277
Release pad (of Assemble) 96
removing objects 58
Repeat Sequence, events 280
Replenish Resource Activity 137–138
Report Menu 49
  Commit to Database 49
  Define Custom Real-Time Plots 49
  Define Global Statistics Collection 49
  Define Real-Time Plots 49
  Display Real-Time Plots 49
  Display Standard Report 49
  Launch Database Application 49
  Launch Plot Application 49
Reports
  ABC 161
  activities 172–175
  attributes 171
  Costs 161
  default 163
  entities 165–169
  resources 169–171
  Standard 163
Resize 22
Resource Downtime
  adding template 206
Resources 126–130
  activities and 54
  adding 73
  adding template 128, 204
  allocation policy 127
  consumable 130
  cost 130
  defining 43, 73, 128
  defining requirements for activities 131
  definition of 19
  downtime 130
  Downtime Schedule 298–308
  entities and 54
  fractional usage 130
  replenishing consumable 137
  usage combinations 132
  variable usage 131, 224
  viewing by activity 41
Retain Batched Entity 101
Run Settings 46, 77, 90
  Cost Periods 46

running a simulation 80
Running a Simulation with Model Parameters 80
Running an Optimization 364

S

scenario 325
Schedule of events 280
schedule, of Generate activity 276
Selected Field 336
sequence of events
  Both must be reached 282
  calendar 282
    entity generation start time 283
    entity generation, start of 283
    start time 283
  definition
  periodic 281–282
    Both must be reached 282
    start time 281
Set Entity Priority To, on Assign activity 108
Set Entity User Attributes, on Assign activity 108
Show Name checkbox 59
Show Text checkbox 61
Simluation Output
  displaying cost results 159
Simulate Menu 46–48
  Animation On 48
  Animation Settings 47
  Change Model Parameters 48
  Pause/Resume 48
  Run 48
  Run Settings 46
  Stop 48
  Verify Model 48
simulation
  animation
    options 81
    settings 81
    showing entities 70
  changing animation options 81
  duration of 69, 77
  End Date 77
  ending 69
  length of, in calendar time 77
  Max Count and 69
  options, run time 77
  Pause 81
  pausing 81
  restart after pause 81
  resuming after pause 81
  run dates 77
  run time settings 77
  running 77–82
  Start Date 77
  starting 80
  stopping 69
  stopping temporarily 81
Simulation (menu item) 81
Simulation Output
  Display Standard Report 163
single event 284
Split Activity 118, 119–122
Standard Output Report 163
StatFit 314
Static Text 141
Statistical Distributions 425
statistical distributions 320
  specifying 64–65
Statistical Output
  Custom Plots 185
  Define Global Statistics Collection 49
  Define Real-Time Plots 49, 176
  Display Standard Report 82
  Displaying Real-Time Plots 179
  Entity Statistics 165
  Process/Activity Statistics 172
  Resource Statisitcs 169
  Simlation Results File 195
Statistical Simulation Experiment 319
  Experimental Data 319
  Mean-Value Analysis 319
Stream 65

Sub-Processes 74–76
  definition of 18
  See also processes, sub-processes
Swimlanes 33
Synchronize Activity 104–106
System Attributes 214

T

Tabular Distributions
  Procedures 88
Template
  defining 199
template, for Document file 60
Templates
  adding 203
  Defining and Editing Templates 199
  editing 207
  resource 204
  resource downtime 206
  structure 201
Terminology 18
Text Block 61
  Show Text 61
Threshold Quantity, of Gate activity 104
Threshold Release, option of Gate activity 104
Time Stamps
  Assembled Entities 310
  assigning 309
  Batched 310
  Definition of 45, 309
  passing to an output entity 310
  Transformed Entities 310
  Viewing Reports 310
Tools Menu 50
Transfer Activity 114–??
Transform Activity 108–110
  Number of Entities Output 109
  Output Entity Type 109
Trigger Assemble, option of Assemble activity 96, 98
Trigger pad, of Gate activity 101
trigger point, of calendar event 283
Trigger Release Quantity, of Gate activity 104
Triggered Release, Gate activity policy 102, 104

U

Unbatch Activity 100, 100–101
Unbatch Nested Batches 100
Use default 277
User Defined Attributes 215
  and Assign Activity 107, 222
  assigning values to 107, 222
  Branch On 111
  copying in Transform activity 110
  globally defining 216–220
  initializing values 241
  locally defining 221
User Defined Distributions
  Procedures 87
  Two methods of creation 87
User Defined Functions 257

V

Verify Model command 80
View function 65
View Menu 41–42
  Activities Hide 41
  Activity Names 41
  Ascend 41
  Connector Names 42
  Descend 41
  Go To Top 41
  Pad Names 42
  Refresh 42
  Resources 41
  View 1 to 1 42
  Zoom In 42
  Zoom Out 42
viewing higher levels 81
viewing lower levels 80

W

Window Menu 52